POWER PLANT ENGINEERING

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Heating, Ventilating and Cooling Plant of the Tivoli Theatre

REFRIGERATION STORAGE CAPACITY ENABLES COMPRESSOR TO HANDLE 100 PER CENT EXCESS PEAK

THE TIVOLI THEATRE, opened to the moving picture-loving public during the last year, is now a byword with every fan, not only in Chicago but in the outlying districts. Its architecture is beautiful and distinctive. The main foyer, for instance, is typical of the architecture employed throughout the building. It is of the Louis XV period and is modeled after the style of the Chapelle at Versailles. To convey some idea of its size, it is 70 ft. or six stories high, 75 ft. wide and 125 ft. long and is capable of accommodating with comfort 1500 people. The theatre proper has a seating capacity of approximately 4000. It was built for Balaban & Katz, of Chicago, at a cost of $2,000,000. The architectural work was done by C. W. and Geo. L. Rapp, also of Chicago.

Passing by the beauty of the place, we go to the inside works, that part which serves to make the theatre comfortable for the patrons—to keep it warm in winter and cool in summer, to maintain an adequate supply of correctly conditioned fresh air at all times. This indispensable service is forthcoming continuously, but it is

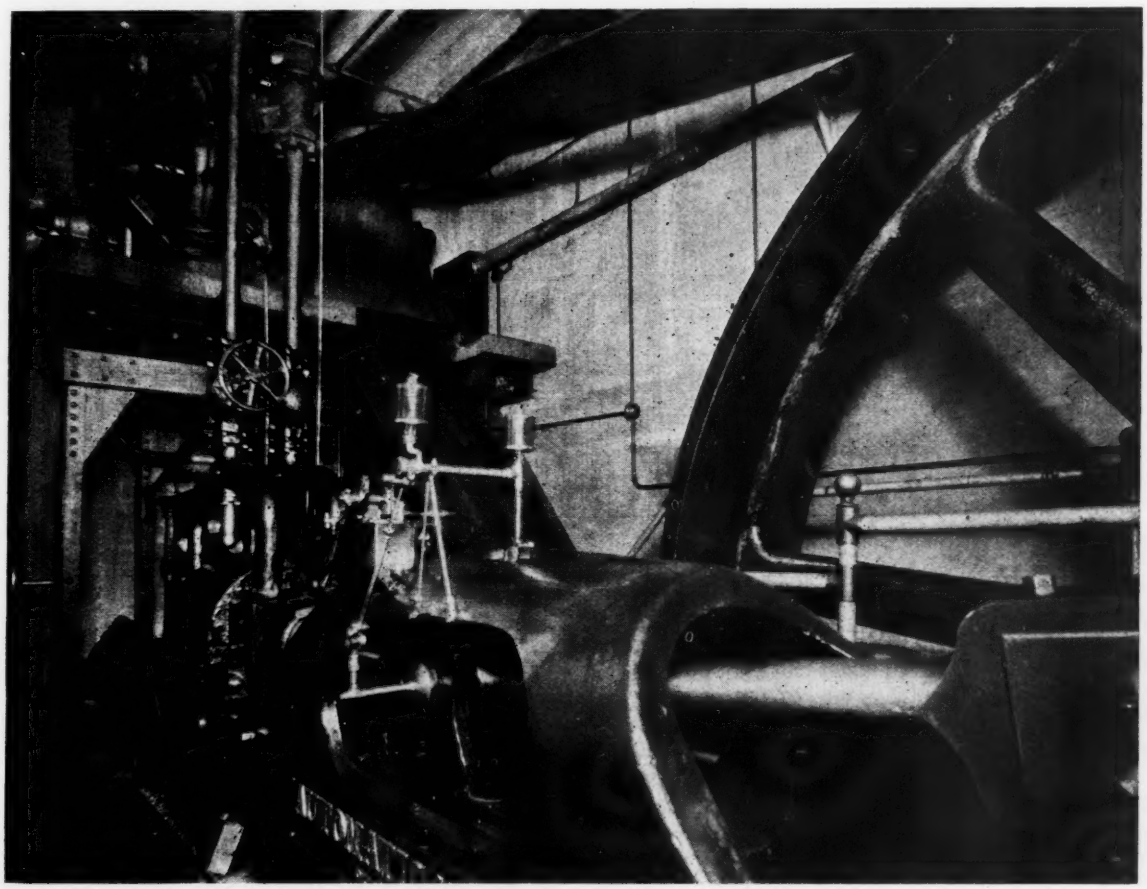


FIG. 1. CRANK END VIEW OF CO_2 COMPRESSOR AND ITS DRIVE

a service which is not in itself manifest and is likely to be taken for granted. These commodities, for such they are, warmth and fresh air, are supplied by the heating and ventilating plant.

The Tivoli theatre has no power plant in the accepted sense, that is, there are no prime movers; all electrical energy for motors and lighting is purchased from outside. The plant consists entirely of apparatus for heating, cooling and ventilating the building, which, excepting for the refrigerating system used for cooling the spray water for washing and cooling the air, was installed by Mehring & Hanson, refrigerating engineers, according to designs by M. C. Hartman, consulting engineer. All of this apparatus is located in a basement beneath the foyer. The main floor of the theatre is built directly on the ground so that this is the only basement in the building.

To contribute further to the well being and comfort of the patrons, there is provided a spray nozzle in the main air duct for the purpose of injecting a fine spray of perfume into the air. Perfume is mixed with compressed air by means of a special mixing valve, the compressor supplying the air. This device, which is made by the Thompson Neeb Mfg. Co., is controlled by clockwork to spray a given quantity of perfume once every hour.

Fresh air is taken in through a large duct along the north wall of the building from a 12 by 12-ft. opening at the north end of the east wall at a point 30 ft. above the alley level. At the inner end of this duct the cold air is passed through a bank of Vento coils where it is preheated to about 50 deg., more or less depending on the temperature and humidity required in the building. It is then passed through an area of fine water spray also having a temperature of about 50 deg., where the dust is removed and where it becomes saturated at the existing temperature. Then, after passing through a series of baffles where any entrained moisture is removed, the air is drawn through three sets of Vento reheating coils by three blowers and is forced to three main divisions of the building, the main floor, the balcony and the main lobby or foyer.

The preheating or tempering coils have an equivalent direct radiation surface of 4112 sq. ft. arranged in four units two stacks deep and two stacks high. The reheating coils are arranged in three separate groups in three ducts, and are individually controlled to give the desired temperature in main section of the house. The orchestra floor coils are arranged two deep and two high and have a total surface of 1820 sq. ft. The balcony coils contain 1190 sq. ft. and the lobby 770 sq. ft., a total of 3780 sq. ft.

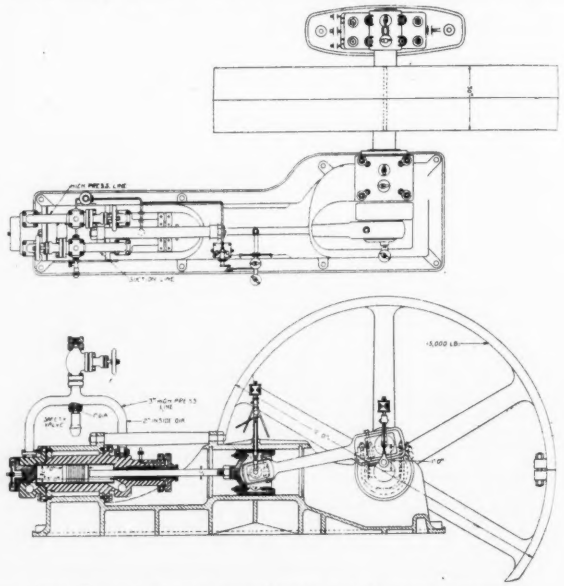


FIG. 3. PLAN AND ELEVATION OF CARBON DIOXIDE COMPRESSOR

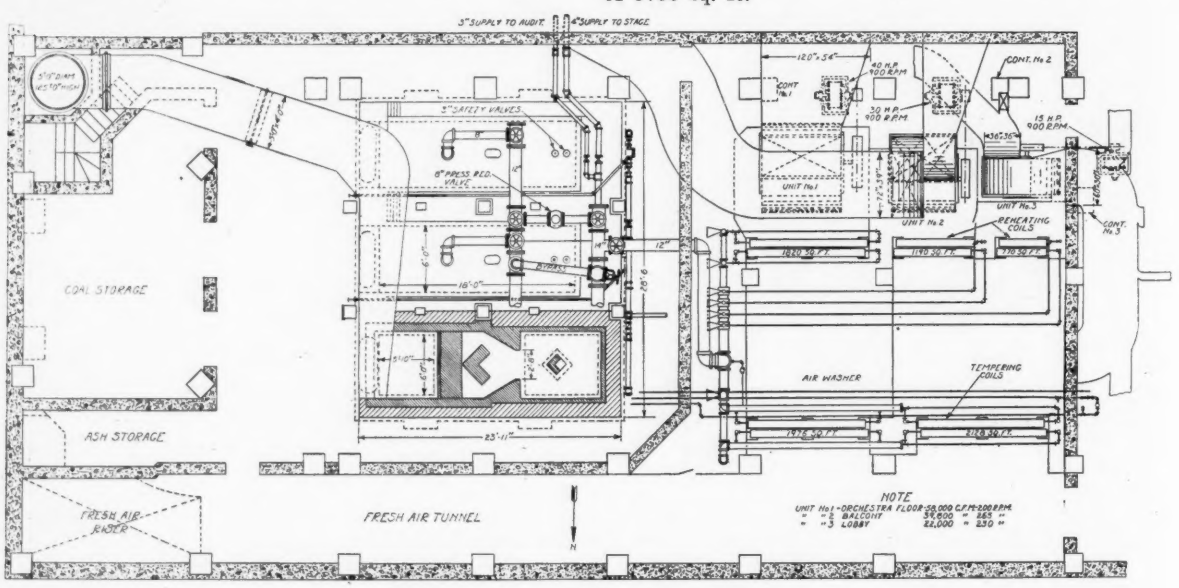


FIG. 2. PLAN OF BOILER AND FAN ROOMS

An automatic bypass damper is provided below each bank of coils so that when but little reheating is required the air may be passed through these openings and thus materially reduce the resistance of the system.

The fans or blowers are all of the Sirocco type made by the American Blower Co. Unit No. 1, the orchestra floor fan, is of the double inlet type and has a rated capacity of 58,000 cu. ft. per min. at a pressure of 1¼ in. water. It runs at 200 r.p.m. and is belt driven from an induction motor having a capacity of 40 hp. at 900 r.p.m. At rated load it uses 100 amp. per phase. The balcony fan, also of the double inlet type, has capacity for 39,000 cu. ft. per min. at 1½ in. pressure. It is belt driven at 265 r.p.m. by a 30-hp. motor running at 900 r.p.m. This motor takes 74 amp. per terminal at rated load. The lobby fan is of the single inlet type and delivers 22,000 cu. ft. per min. at 1¼ in. It runs at 230 r.p.m. and is belt driven by a 15-hp. motor running at 900 r.p.m.

The ducts leading from the fans are of such size as to give velocities not to exceed 1000 ft. per min. which has been found a safe maximum allowable where quietness of operation is desirable or essential as in this installation. To eliminate as far as possible the noise incident to the operation of the blower from being carried to the house, a canvas neck is inserted in the duct at the outlet of the fan. The layout of this apparatus is shown in Fig. 2.

The temperature of the air discharged from the balcony and main floor fans is kept virtually the same at about 70 deg. while that from the lobby fan is somewhat less. To maintain an even temperature of air delivered to the main floor, supplementary heaters are provided at the entrance of each fresh air supply tunnel, under the floor, from which separate ducts lead to mushroom vents. These conditions are for winter. During the summer months, the lobby is kept several degrees warmer than the rest of the house, which is maintained at a higher temperature than in winter—about 74 or 75 deg.

The temperature in the theatre is controlled from multiple thermostats which are located in the duct behind the reheaters.

In the manager's office a switchboard is arranged so that by operating push buttons located on this board, the duct thermostats may be set for any desired temperature between 62 deg. and 72 deg. and if so desired can cut off the thermostatic control entirely, allowing the full heating effect of the coils to be used for rapid heating of the theatre. The lobby fan is controlled by a multiple thermostat in conjunction with a pilot thermostat which, when the temperature in the lobby reaches a predetermined point, allows the duct thermostat to operate and furnish air at 68 to 70 deg., as desired, for ventilation, and if the temperature drops below the desired point in the lobby the pilot thermostat cuts off the duct thermostat and allows the full heating effect of the coils to be utilized.

The system has, in connection with the fans, dampers which operate to allow fresh or recirculated air to be used with the ventilating system. These switches are of the two-point type which allow the dampers to be held closed, half open, or full open. This allows the use of all fresh air or part fresh air and part return air or all return air. The dampers are furnished by the Johnson Service Co., and are operated by pneumatic switches on the same switchboard as the thermostat adjusting devices. Compressed air is furnished to the temperature control system by means of electrically driven air compressor units, which are automatic in their operation.

Used air is exhausted partially by natural convection through ventilators on the roof and partially by means of an exhaust fan located on the upper balcony level, which is capable of handling 50,000 cu. ft. per min. It is driven at 153 r.p.m. by a 25-hp. induction motor running at 600 r.p.m. This fan discharges through a vertical shaft through two sets of automatic louvered dampers either up to the atmosphere or down to the fresh air intake duct, there to be mixed with the fresh air and recirculated. These dampers are regulated from the engineer's office to allow any proportion of recirculated air to be used. Ducts leading to this fan are so proportioned that 30,000 cu. ft. per min. are taken from the balcony and 20,000 from the main floor. Adjacent to this main exhaust is a 3-hp. exhauster which

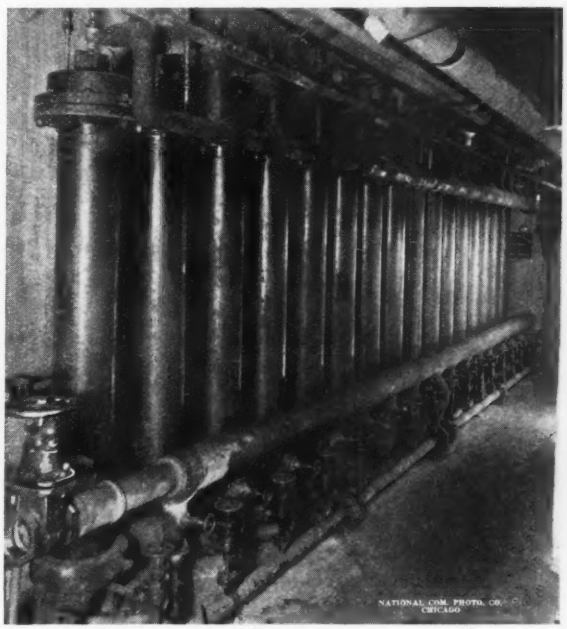


FIG. 4. BATTERY OF SIXTEEN 10-T. CONDENSER UNITS

removes 4600 cu. ft. per min. from the toilets. Another 3-hp. fan located back stage handles 2500 cu. ft. per min. from the stage and wings.

In addition to the 4112 sq. ft. of tempering and the 3780 sq. ft. of reheating coils, there is distributed throughout the house, principally along the walls, 6200 sq. ft. of heating surface primarily to take care of the wall losses. The total heating surface of 14,092 sq. ft. is supplied with steam at 4 or 5 lb. pressure, depending on the amount of heat required, through a reducing valve from a battery of three 150-hp. boilers, also shown in Fig. 2.

These boilers are located in the east section of the basement under the balcony. They are of the horizontal return tubular type, 72 in. diameter and 18 ft. long containing seventy-four 4-in. tubes. This gives a tube surface of 1395 sq. ft. and an effective shell area of 170 sq. ft. totaling 1565 sq. ft. which, at a 10 sq. ft. builders' rating, gives a little over 150 hp. Steam is generated at 10 lb. pressure, is taken off through 8-in.

leads and after being reduced is collected in a 14-in. header from which a 12-in. supply to the Vento coils and other sundry direct radiation mains are taken. There are two 3-in. safety valves on each, set to blow at 12 lb. pressure.

The furnace setting is what is known as the Chicago Standard No. 8 setting. The grate, designed for hand firing, is 6 ft. wide and 5 ft. 10 in. deep, giving an area of 35 sq. ft. It is 2 ft. 2 in. off the boiler room floor and 3 ft. below the boiler shell. The bridge wall at the end of the grate extends to within 18 in. of the shell. Back of this the combustion space is divided in half by a pier which extends to within 1 or 2 in. of the shell. On each side there is left a space 14 in. wide for the passage of the gases of combustion. Immediately behind this pier the side walls converge to mix the two streams. The minimum width of the gas passage here is 2 ft. 8 in. As the height at this point is

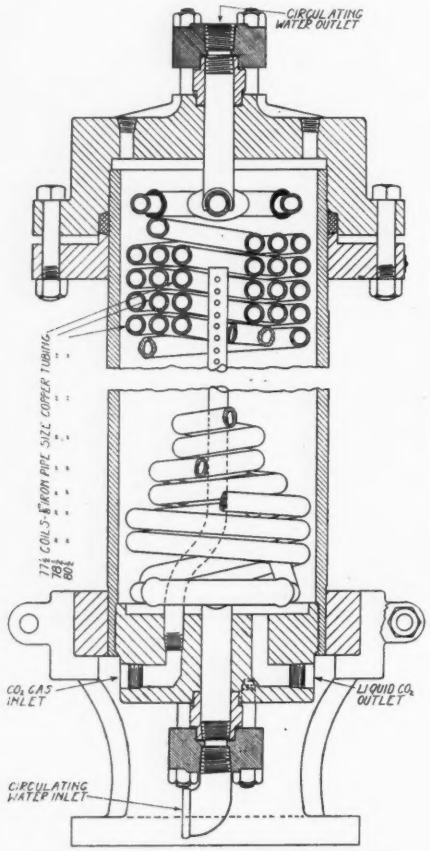

CIRCULATING WATER OUTLET
11½ COILS 1" IRON PIPE SIZE COPPER TUBING
CO₂ GAS INLET
LIQUID CO₂ OUTLET
CIRCULATING WATER INLET

FIG. 5. SECTION OF CONDENSER UNIT

5 ft. 1 in., the area is 13.5 sq. ft. or only 39 per cent of the grate area. From this throat the furnace gases expand into a secondary combustion chamber, where combustion is completed. From here the gases return through the flues to the breeching which has a maximum area, at the base of the stack, of 20 sq. ft. The stack is 125 ft. high and has an area at the top of 19.6 sq. ft.

The Pocahontas coal used is stored in a bin across the firing aisle from the boiler fronts. It is delivered in trucks and dumped directly into the bins through manholes in a driveway on the alley level. Ash is stored in a small bin alongside the coal storage. Periodically, it is lifted to the surface in buckets by means of an electric hoist, loaded onto trucks and carted away.

At the present time, even with the outside temperature not far above zero, it has been found necessary to use only one of the boilers. During the months of December and January the average coal consumption was 2.37 T. per day, which corresponds to an average rating of about 130 hp.

Condensate from the heating system is returned under vacuum to a receiving tank in the compressor room and from there pumped back into the boiler. Vacuum is maintained by a 35 amp. 5-hp. vacuum pump of the rotary type running at 155 r.p.m.

Refrigerating Unit

The refrigerating system employed to effect the cooling of the spray water used for cleaning and saturating the ventilating air is of the CO_2 type. The compressor, a view of which is shown in Fig. 1 and a plan and elevation in Fig. 3, was built by the Automatic Carbonic Machine Co. It is of the horizontal double-acting type and has a rated capacity at 84 r.p.m. of 150 T. This unit is driven by a 27-in. open belt from a General Electric 150-hp. slip ring induction motor which is mounted on a platform about 10 ft. from the floor, near the head end of the compressor. The motor operates on three-phase, 220-v., 60-cycle current, just as the other motors in the plant, and requires about 400 amp. per terminal.

The compressor has a bore of 7¼ in. and a stroke of 24 in. At this speed, the compressor handles 96 cu. ft. of gas per min., or 405 lb. at 25 atmospheres pressure.

On account of the high pressures encountered and the great variation in the resisting torque, the machine is equipped with a heavy 12-ft. flywheel having a face 30 in. wide, and weighing 15,000 lb. to impose a more even resisting moment on the motor.

The safety valve in the discharge line is of a design not ordinarily met with in other classes of work where lower pressures are encountered. Besides a regular spring loaded pop valve there is in series with it and on the atmospheric side a thin phosphor-bronze diaphragm about 0.010 in. thick and about ⅝ in. in diameter which ruptures when the compressor pressure reaches a certain pre-determined maximum and allows the CO_2 to escape to atmosphere. The pop valve is simply used for the purpose of preventing excessive loss of the refrigerating medium. It is of course necessary to replace the diaphragm after every rupture. The object of the double valve is to prevent constant loss of gas at operating pressures due to leakage past the pop valve.

Ordinarily a source of much annoyance in the operation of a CO_2 compressor is the leakage past the piston and stuffing-box. To eliminate this loss to as great an extent as possible, the piston is made exceptionally long, 12 in. in this case, and is provided with six leak-proof piston rings. The piston rod is packed with 15 in. of special packing. Pressure adjustment on the packing to suit the temperature of the rod is obtained by screwing in or out the gland. The gland is turned by means of worm gearing, the worm being turned by means of a crank.

In making a choice of the refrigerating plant for this installation, the ammonia system was discarded and

the engineers on the job handed down a decision in favor of carbon dioxide as the refrigerating medium to be used for a number of reasons. The principal one was that the space available was rather inadequate and a machine had to be chosen which would give the required capacity with a minimum amount of floor space. The space required for the condenser for CO_2 gas is much less than that for ammonia because copper tubing can be used in the first case which may have a much smaller surface on account of the greater heat conducting quality.

In a public building of any kind, the escape of ammonia gas is highly undesirable and dangerous to life if present in any appreciable quantities. On the other hand, slight leakage of carbon dioxide is unnoticeable on account of its lack of odor and is not dangerous unless present in relatively large quantities. It was for these reasons then that a CO_2 system was employed.

The compressed gas at a pressure of from 70 to 76 atmosphere or 1030 to 1120 lb. abs. is piped over the storage tank to a battery of condensers also supplied by the Automatic Carbonic Machine Co. along the west wall of the building and just south of the storage tank, as shown in Fig. 4. There are 16 individual condensers in this battery, each having a capacity of 10 T., a section of which is shown in Fig. 5. The condenser is of the vertical shell and tube type which requires a small amount of floor space of 3 by 24 ft. or 72 sq. ft. as compared with about 320 sq. ft. required for a double pipe condenser. Including all fittings, etc., a condenser unit of this type can be installed in about 35 per cent of the volume required for a double pipe type.

The condenser consists of a 9-in. extra heavy steel pipe ½ in. thick which forms the shell, on which are fitted two cast-steel manifold heads. The lower head has connections for gas inlet, liquid outlet and circulating water inlet. The top head is provided with a circulating water outlet connection. Three copper coils arranged in parallel conduct the cooling water through the shell from bottom to top. CO_2 gas enters at the bottom at the center of the head and ascends through a riser to near the top of the shell. Here the gas escapes to the shell where it comes in contact with the cold coils and is condensed. The condensate collects at the bottom and is piped to a main liquid header at the top of the storage tank. From here it is admitted through four ¾-in. so-called pressure relation valves, or expansion valves, to the expansion coils in the tank. After evaporation, the gas is drawn off at a pressure of from 20 to 26 atmospheres through a collecting header and enters the compressor.

The storage tank is 12 ft. 8 in. wide by 28 ft. long by 12 ft. high and has a volume of 4250 cu. ft. In it is disposed 15,000 ft. of 1¼-in. extra heavy expansion piping which, with the return bends, occupies a space of about 250 cu. ft., leaving a net volume of 4000 cu. ft., which, when filled to the top will accommodate 250,000 lb. of water.

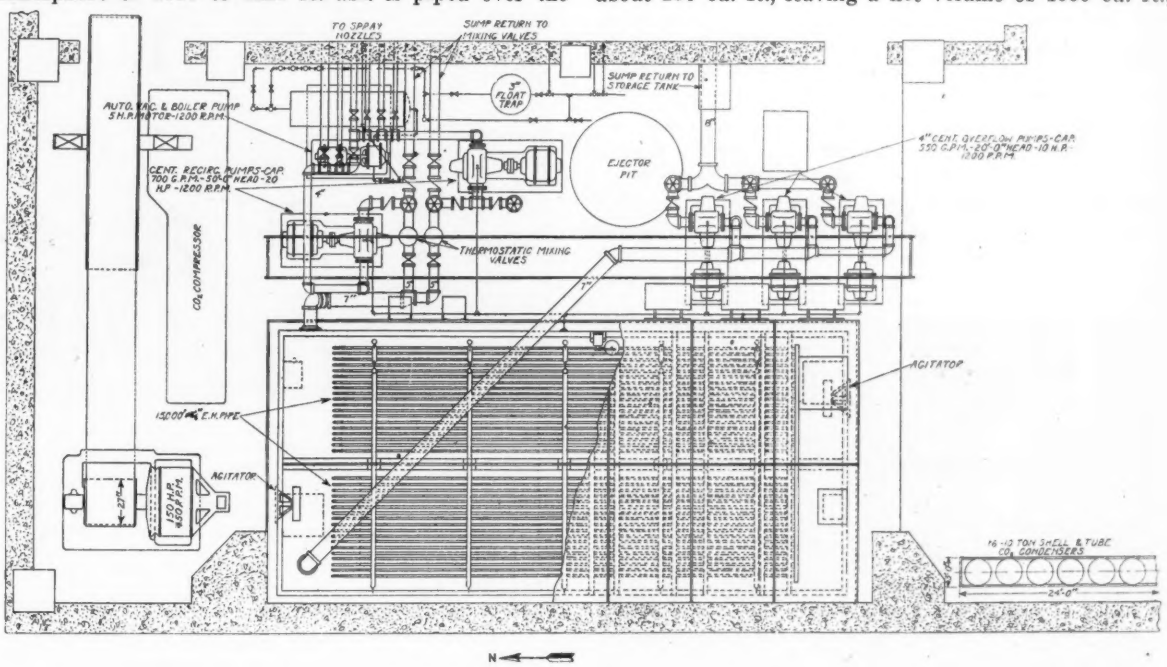

TO SPRAY NOZZLES
SUMP RETURN TO MIXING VALVES
SUMP RETURN TO STORAGE TANK
3" FLOAT TRAP
AUTO. VAC. & BOILER PUMP 5 H.P. MOTOR-1200 R.P.M.
CENT. RECIRC. PUMPS-CAP. 700 G.P.M.-50-0" HEAD-20 H.P.-1200 R.P.M.
CO2 COMPRESSOR
EJECTOR PIT
4" CENT. OVERFLOW PUMPS-CAP. 550 G.P.M.-20'-0" HEAD-10 H.P. 1200 R.P.M.
THERMOSTATIC MIXING VALVES
AGITATOR
15000 LIN. FT. E.H. PIPE
AGITATOR
150 H.P. 450 R.P.M.
16-10 TON SHELL & TUBE CO2 CONDENSERS
24'-0"
N

FIG. 6. PLAN OF PUMP AND COMPRESSOR ROOM SHOWING STORAGE TANK AND CONDENSER

During the hot afternoons of the summer months, the load on the cooling system is increased tremendously and frequently the system is called upon to meet a peak of 250 T. refrigerating capacity. There are conditions which arise at times which require as much as 300 T. These are peak conditions and have to be met for only an hour or two a day. If a compressor were installed to take care of this maximum demand, it would mean that most of the time, the compressor would be working at much less than its rated capacity with a consequent loss of efficiency. Owing to the fact that the theatre is open from 2 p.m. to 12, or 10 hr., a full capacity machine would be idle the rest of the time or 14 hr. a day, which of course means heavy stand-by charges. In order,

then, to increase the capacity factor and the efficiency of the machine and to decrease the cost of current incident to the high maximum demand of a full capacity compressor, a refrigerating machine of only 150 T. rating was installed, in conjunction with a storage system.

With this storage arrangement, a much smaller compressor is practical and although the initial investment is virtually the same, when the added cost of the tank is considered, the compressor can operate for a much longer period. For normal summer operation, the compressor is started up at about 7 a.m. and from that time until the load comes on is building up a reserve. Thus the compressor runs 17 instead of 10 hr. a day and the capacity factor is increased from about 42 per cent, which would be realized with a 250-T. compressor and no storage, to about 71 per cent with a 150-T. machine and storage capacity.

By starting at 7 a.m. and storing cooling capacity in the tank until 2 p.m., 12,600,000 B.t.u. cooling capacity is stored. During this time, the water will be cooled from an average maximum temperature of 55 deg. to 32 deg. and after that about 47,000 lb. of ice will be made. When the demand comes on at 2 o'clock, about ½ in. of ice will have formed on the expansion coils. This ice maintains the water temperature at 32 deg. until about 7:00 or 7:30 p.m., after which the compressor carries the load practically unaided. The water temperature gradually rises, however, until at midnight it has reached its maximum of about 55 deg.

Cold water flows from the bottom of the storage tank through a 7-in. line to the suction of either one or both

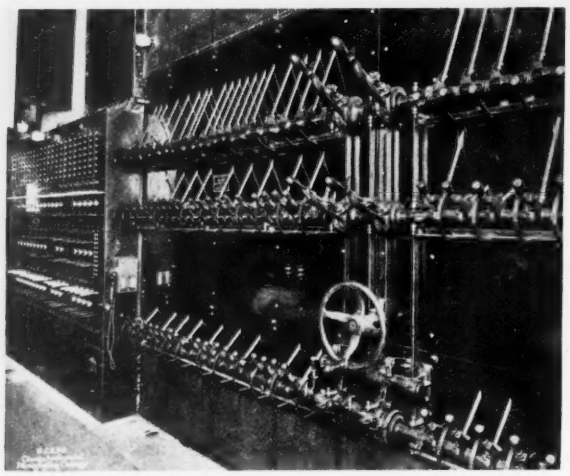


FIG. 7. LIGHT DIMMER COTROL

of two Pennsylvania centrifugal pumps shown in the plan of the pump room, Fig. 6, having a capacity of 700 g.p.m. each under a head of 50 ft. Each is direct connected to a 20-hp. induction motor having a normal speed of 1200 r.p.m.

The temperature of the water to the spray nozzles is controlled by two thermostatically operated mixing valves located in the suction valve line. These valves mix return water from the spray chamber sump with that from the storage tank in correct proportion to give the desired spray temperature.

Surplus water in the sump is pumped back to the storage tank by any one or all of three centrifugal pumps with capacity for 550 g.p.m. each. These pumps work against a 20-ft. head and are directly connected to 10-hp. motors which run at 1200 r.p.m. When 100 per cent cold water is used for the spray the return pumps handle the same amount of water as the supply pumps. As the maximum capacity of the latter is 1400 g.p.m. and of the former 1650, there is never danger of flooding the spray sump.

The return pump motors are automatically controlled by float switches in the sump tank. When the level in this tank reaches 18 in., a float switch closes the circuit on one of these pumps and starts it. If the water continues to rise, the second pump is thrown in at 26 in. At a level of 28 in., the third is cut in and as the return is then in excess of any possible input, the level falls.

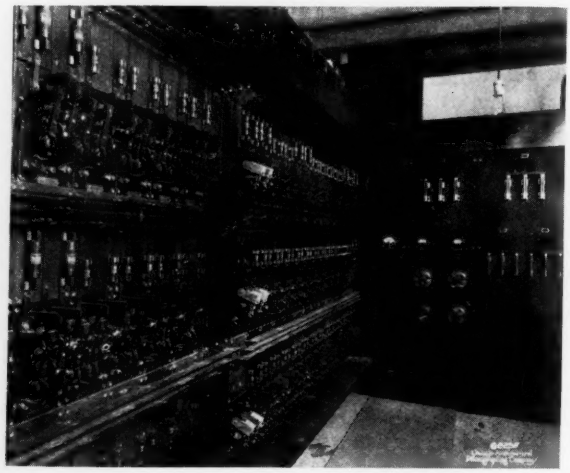


FIG. 8. HEAVY CURRENT SWITCHBOARD

In a test made on the cooling system with all fans on at a maximum capacity of approximately 150,000 cu. ft. per min., the following average and total results were observed:

Duration—min.	88
Head pressure—atmospheres	75
Suction pressure—atmospheres	32
Temperature condensing water in—deg. F	70.5
Temperature condensing water out—deg. F	85.5
Temperature difference—deg. F	15
Quantity circulating water cu. ft. per min	39
Temperature water to storage tank—deg. F	57
Temperature water from storage tank—deg. F	43
Temperature difference—deg. F	14
Water circulated—lb. per min	2710
Average kilowatt input to motor	165
Temperature air in—deg. F	72
Temperature air out—deg. F	64
Temperature difference—deg. F	8

When the difference between the temperatures entering and leaving the tank became constant at 12½ deg., the machine showed capacity of 170 T.

Electrical Equipment

To one who has witnessed the lighting effects produced in this theatre as an integral part of the program, the impression is beautiful beyond comparison. The

delicate blending of the three prime colors, red, amber, and blue, and the gradual changes of intensity is like music.

Investigating briefly the mechanism that produces these effects, we find behind the wings a switchboard shown in Fig. 7 equipped with numerous switches controlling various light banks on the stage and throughout the theatre. These switches were designed and made by the Major Equipment Co. and were installed by the Hub Electric Co. As will be seen there are three tiers of control switches, each tier controlling one particular color. Each vertical row controls a certain section or bank of lights.

Adjacent to this board is the dimmer panel containing graduated controls for cutting in any amount of resistance on any circuit to produce any desired intensity. Each group may be controlled separately or they may all be interlocked with a master control for changing all the lights at once. This master is provided with a slow motion control so that the rate of change of intensity may be reduced to the point where it is scarcely perceptible. The control is of the remote type; only a small current is carried on this board to eliminate as far as possible the danger incident to the operation of heavy current apparatus. All heavy current switching is done on a special set of panels shown in Fig. 8 located in a vault below. Here are located the main cutout switches supplying the motors in the fan room, the motor-generator sets in the projection room, and the lighting circuits.

Distributing Power Charges---II

DESCRIBING IN DETAIL AN EMERGENCY METHOD OF DISTRIBUTING POWER CHARGES IN A LARGE MANUFACTURING PLANT. BY WILFRED A. MILLER

IN THE preceding article, the author discussed the reasons for compiling certain tables showing data in regard to operation and costs in the various departments throughout the plant.

The readiest means of showing the steps required actually to apply the information contained in the various tables, will be to give a transcript of the instructions which were issued for the guidance of the clerk whose duty it was to get out the monthly statement of power cost distribution, as illustrated in Figs. 2 to 7, inclusive.

METHOD OF MAKING MONTHLY DISTRIBUTION OF POWER COSTS AMONG THE VARIOUS DEPARTMENTS OF THE PLANT

STEP 1.

Obtain the data designated by symbols A to N, a to m, and P to Q below.

SYMBOL	DESCRIPTION	SOURCE
A	Coal used by Boilers in Large Boiler House, in Tons	Factory Ledger
B	" " " " " Small " " " "	do
C	Cost of Coal used in Large Boiler House	do
D	" " " " " Small " "	do
E	" " Total Water Used	do
F	" " Labor used in Large Boiler House	do
G	" " " " " Small " "	do
H	" " " " " Main Engine Room	do
I	" " " " " Engine Room of Dept. B	do
J	" " " " " " " " Dept. C	do
K	" " " " " " " " Dept. G	do
L	" " Total Repairs made to Power Equipment	do
M	Miscellaneous Items of Power Cost	do
N	Burden Charges to Power	do
a	Man-Hours in Dept. A	Pay Roll Summary
b	" " " Dept. B	do
c	" " " Dept. C	do
d	" " " Dept. D	do
e	" " " Dept. E	do
f	" " " Dept. F	do
g	" " " Dept. G	do
h	" " " Dept. H	do
i	" " " Dept. I	do
j	" " " Dept. J	do
k	" " " Dept. K	do
l	" " " Dept. L	do
m	" " of Miscellaneous Labor	do
P	Alternating Current Generated, in Kw.-Hrs.	Chief Engineer
Q	Direct " " " " "	do

FIG. 2. STEP 1. INFORMATION REQUIRED FOR TABLES I, II AND III

Step 1 consists of looking up in the records the information for the current month necessary to make the computations that follow. This information will be recognized as being that laid out in Tables I, II and III, which appeared in the Feb. 15 issue.

STEP 2. FIGURES NECESSARY FOR ARRIVING AT TOTAL EXPENSE OF GENERATING UNITS

IN STEP 2 the items of cost C and N are entered in a table in such a way as to arrive at the total expenses incurred by the various generating units, that is, the boiler rooms, engine rooms, and so on, these totals appearing in the last column. The information contained in the Accounting Department records gave only the entire amounts of the repairs, miscellaneous charges and burden charges (represented by L, M and N), and

STEP 2.

Construct a table similar to Table A below, and enter in it the values of symbols C to N as indicated.

TABLE A

Description	Coal	Water	Labor	Repairs	Misc.	Burden	Total Indirect Expense	Grand Total
Large Boiler House	C	(502)	F	-	-	-	(505)	(509)
Small Boiler House	D	(503)	G	-	-	-	(506)	(510)
Main Engine Room	-	-	H	-	-	-	(507)	(511)
Dept. B Engine Room	-	-	I	-	-	-	-	I
Dept. C Engine Room	-	-	J	-	-	-	-	J
Dept. G Engine Room	-	-	K	-	-	-	-	K
Total	(501)	E	(504)	L	M	N	(508)	(512)

STEP 3.

Compute the values of the remaining entries in Table A in the manner given below, and enter them in that table.

(501) = C+D
(502) = $\frac{C}{(501)}$ * E
(503) = E-(502)
(504) = F+G+H+I+J+K
(505) = $\frac{1}{2}$ * (508)
(506) = $\frac{2}{12}$ * (508)
(507) = $\frac{1}{12}$ * (508)
(508) = L+M+N
(509) = C+(502)+F+(505)
(510) = D+(503)+G+(506)
(511) = H+(507)
(512) = (509)+(510)+(511)+I+J+K
= (501)+E+(504)+(508)

STEP 4.

Compute the values of the quantities enumerated below. The value of q will be found in Table XI of the data appended to these instructions.

SYMBOL	METHOD OF COMPUTATION
t	2240 * q * A
u	2240 * q * B
v	P+Q

FIG. 3. STEPS 2, 3, AND 4

not the portions thereof applicable to the various units. It was therefore decided to combine the totals into one item of indirect expense, and then divide this according to some predetermined ratios. An analysis of the duties of the individuals on the power plant payroll over a considerable interval of time, as also of the composition of the burden, led to the derivation of a set of ratios which were made to apply to the miscellaneous charges, too, for want of a more satisfactory

STEP 5.

Compute the values of the expressions contained in the following schedule. The values of n, p, r and s will be found in Table II of the data appended to these instructions.

SYMBOL	METHOD OF MAKING COMPUTATIONS DURING MONTHS THAT BUILDINGS ARE HEATED.	METHOD OF MAKING COMPUTATIONS DURING MONTHS THAT BUILDINGS ARE NOT HEATED
R	$n \times \left\{\frac{(509)}{t}\right\}$	No Value
S	$p \times \left\{\frac{(510)}{u}\right\}$	No Value
T	$\left\{\frac{(509)}{t}\right\} \times \left\{t - r+v - n\right\}$	$\left\{\frac{(509)}{t}\right\} \times \left\{t - r+v\right\}$
U	(510) − S	(510)
V	$\left\{\frac{s}{v}\right\} \times \left\{(509)+(511)-R-T\right\}$	$\left\{\frac{s}{v}\right\} \times \left\{(509)+(511)-T\right\}$
W	(509)+(511)−R−T−V	(509)+(511)−T−V

STEP 6.

Enter the values of symbols a to m and of R to W in a table in the manner indicated in Table B below.

TABLE B

DEPT.	COLUMN NUMBERS											
	14	15	16	17	18	19	20	21	22	23	24	25
A	–	a	a	–			–		–			
B	b	–	b		–			–	(601)	–		
C	c	–	c		–			–	(602)	–		
D	d	–	d		–			–		–		
E	e	–	e		–			–		–		
F	f	–	f		–			–		–		
G	g	–	g		–			–	(609)	–		
H	h	–	h		–			–		–		
I	–	i	i	–			–		–			
J	j	–	j		–			–		–		
K	k	–	k		–			–		–		
L	l	–	l		–			–		–		
Misc.	m	–	m		–			–		–		
Totals	(601)	(602)	(603)	(604)	(605)	(606)	R	S	T	U	V	W

FIG. 4. STEPS 5 AND 6

basis for their distribution. Under this scheme it became unnecessary to compute each unit's share of the repairs, the miscellaneous charges, and the burden, as separate items, since the total could be arrived at by simply splitting the total of L, M and N in the ratios decided on. Hence no entries appear in the individual columns other than the totals at the foot. It should here be pointed out, that although the supervision of the auxiliary units in Departments B, C and G, and the payrolls thereof, came under the jurisdiction of the power plant organization, the indirect expenses incurred by them were absorbed in the burden of the departments which they served. This introduced a slight discrepancy into the amount of the indirect expense applicable to electrical generation, which, however, was of insignificant proportions. This accounts for the fact that the grand total expense for these auxiliary units is composed of labor only.

STEP 3. INSTRUCTIONS FOR USING ENTRIES IN TABLE A

STEP 3 contains instructions for using the entries made in Table A. Thus, (501) is merely the footing of the amounts in the first column, namely, C and D. Likewise (504), (508) and (512) are simply additions of columns. In the case of water (502) and (503) indicate the split in the total water expense E. The total only appeared in the books and to split it no better method was suggested than to make the division in the same ratio as that of the coal used. Hence (502) was made equal to $E \times C \div (501)$, as indicated, and of course (503) would have to be equal to the remainder, namely, E — (502). The ratios for the split of the indirect expenses, as finally worked out, proved to be 21 : 3 : 4 for Battery No. 1, Battery No. 2, and the generating room, respectively, giving as the proportionate parts of the whole, 21/28, 3/28 and 4/28, or 3/4, 3/28 and 1/7. These are the fractions by which (508) must be multiplied to find the values of (505), (506) and (507), respectively, as indicated in the instructions. As already stated, (508) in itself is the sum of L, M and N. The values of (509), (510) and (511) are merely cross additions of the individual items on each of the lines. A check on the accuracy of the work is had through the fact that (512) must be equal to the cross addition of its line as well as being the addition of the column above it.

STEP 4. INTERMEDIATE QUANTITIES

IN STEP 4 some intermediate quantities are determined in order to simplify computations to be made further on. Thus, t represents the total weight of steam generated by Battery No. 1. It is equal to the number of tons of coal used by the battery in the month, namely, A, multiplied by the number of pounds per ton, that is 2240, to get the total pounds for the month, which weight in turn is multiplied by q, the evaporation per pound of coal, as stated in Table VI, Feb. 15 issue.

STEP 7.

Compute the values of the entries to be made in columns 17 to 21, inclusive, and in column 24 of Table B, by using the values contained in Table C below, in the manner described in the instructions that follow it.

TABLE C

DEPT.	COLUMN NUMBERS					
	1	2	5	11	12	13
A	–	95.4	13.3	–	1.936	2.217
B	29.4	–	2.0	2.697	–	1.090
C	None	–	2.5	5.886	–	–
D	0.5	–	9.2	0.032	–	3.134
E	5.8	–	4.2	0.135	–	0.717
F	5.5	–	5.0	0.367	–	1.907
G	15.3	–	5.8	2.230	–	0.538
H	2.1	–	5.0	1.450	–	0.750
I	–	4.6	3.3	–	0.072	0.097
J	1.8	–	3.3	0.014	–	0.128
K	10.6	–	7.5	0.009	–	0.273
L	5.5	–	0.8	None	–	0.273
Misc.	23.5	–	20.1	None	–	0.846

To determine the entries in column 17, multiply the corresponding entries in column 14 by the corresponding ones in column 11.

To determine the entries in column 18, multiply the corresponding entries in column 15 by the corresponding ones in column 12.

To determine the entries in column 19, multiply the corresponding entries in column 16 by the corresponding ones in column 13.

To determine the entries in column 20, multiply the corresponding entries in column 1 by R.

To determine the entries in column 21, multiply the corresponding entries in column 2 by S.

To determine the entries in column 24, multiply the corresponding entries in column 5 by V.

FIG. 5. STEP 7

Similarly u is the weight of steam generated by Battery No. 2. The value of v is merely the total electrical energy for the month, that is, the sum of P and Q.

STEP 5

BY MEANS of Step 5 the grand total expense (512)—or, to be more accurate, that part of it composed of (509, (510) and (511), that is, omitting I, J and K, the reason for whose exclusion will appear later—is divided into the parts given below:

R—Cost of heating derived from Battery No. 1.
S—Cost of heating derived from Battery No. 2.
T—Cost of steam power derived from Battery No. 1.
U—Cost of steam power derived from Battery No. 2.
V—Cost of electricity for lighting.
W—Cost of electricity for power.

In using the expressions given in Step 5, consideration must be given to the time of year, that is, whether the month is one in which heating is required or not. So far as the border months are concerned, a month is to be considered as a heating month if the steam is on for half the month or more, and as an unheated month if on for less than half the month. During heating months the cost of Battery No. 1, that is R, is figured from the constant radiation load given by n in Table VI. Since n is expressed in pounds of steam it is merely necessary to multiply it by the cost per pound to get the heating cost. The cost per pound is the total expense incurred by Battery No. 1, that is R, is figured from the constant radiation load given by n in Table VI Since n is expressed in pounds of steam it is merely necessary to multiply it by the cost per pound to get the heating cost. The cost per pound is the total expense incurred by Battery No. 1, namely (509, divided by the total steam generated which is given by the quantity t as derived in Step 4. Hence, $R = n \times (509) \div t$ as shown. Similarly the cost of furnishing the heat derived from Battery No. 2 is $S = p \times (510) \div u$. Of course, during the non-heating months these calculations are eliminated.

The cost T, of steam furnished to the various mills for power by Battery No. 1, is manifestly equal to the total expense incurred by it, less the cost of steam furnished for electrical generation and for heating. The cost is therefore most simply arrived at by obtaining the net quantity of steam used for power and multiplying by the cost per pound, which has already been shown to be equal to $(509) \div t$. The total steam is also already known, being t, as is the steam for heating, n. It remains to determine the steam used for electrical generation. This is obtained by multiplying the total kilowatt-hours, given in Step 4 as $v = P + Q$, by the pounds of steam per kilowatt-hour, corresponding to the factor r in Table VI. Hence, the steam for power is equal to $(t - rv - n)$ lb., which multiplied by the cost per pound, $(509) \div t$, gives the expression for T contained in the schedule. During non-heating months the heating cost, n, drops out, so that the total for power becomes simply $(509) \div t \times (t - rv)$ as indicated in the second column.

As there is no electrical load on Battery No. 2, the steam power cost U, is equal to the total cost less the heating cost in winter, and equal to the entire cost in summer.

The cost of lighting V, is computed from the fixed lighting load represented by s in Table VI and the cost of electricity per kilowatt-hour, which is obtained by dividing the total cost of electrical energy for the month by the number of kilowatt-hours generated. The total cost is the cost of steam used plus the main engine room expenses. The readiest means of obtaining this figure is to take the entire expense for Battery No. 1, add to it the engine room expense, and subtract from this total the cost of steam for heating and power as already computed for R and T. That is, the total expense for electricity would be $(509) + (511) - R - T$. The total number of kilowatt-hours generated being v, the cost per kilowatt-hour would be $\frac{(509)+(511)-R-T}{v}$, hence the lighting cost would be s times this rate, giving the expression contained in the schedule, where it is arranged slightly differently to present an appearance less clumsy than the foregoing one. In the non-heating season no deduction for heating would be made, causing the elimination of R as a factor in the calculation.

The cost W, of the electrical energy used for power purposes is most readily arrived at by deducting the lighting cost from the total electrical cost. Since the latter has already been shown to be equal to $(509) + (511) - R - T$, it follows that the power cost is obtainable by merely subtracting V from this expression as has been done in the schedule. In non-heating months R has no value and therefore drops out as already explained.

It will be noted that the method here used does not take into consideration the steam consumption of the power plant auxiliaries. Thus, the total evaporation t is divided into the total cost (509) to get a cost per pound of steam. Theoretically, of course, the power plant use should have been subtracted from t before establishing a rate, but it was felt that practically nothing would be gained thereby since the entire power expense must in any event be distributed and is distributed on the basis of theoretical consumption against actual cost. Some degree of inaccuracy is of course introduced, but in view of the limitations of the method it was concluded that the unbalancing of the distribution due to this cause was of no practical importance, particularly in the face of the added complications in the calculations that would result from an endeavor to give weight to it.

STEP 6. DISTRIBUTING COSTS AMONG DEPARTMENTS

AFTER THE computations required by Step 5 have been completed, all information necessary to distribute the costs among the departments is at hand. Table B of Step 6 furnishes a convenient form for making this distribution. Into columns 14, 15 and 16 are transcribed the book amounts found for the departmental man-hours a to m. It will be noted that columns 14 and 15 combined contain precisely the same figures as column 16 alone. The purpose of this repetition, it will be remembered, is to make possible the allocation of the steam loads drawn from the two batteries of boilers and of the electrical load, column 14 being used for Battery No. 1, 15 for Battery No. 2, and 16 for electrical service. As a matter of fact, column 16 alone would at this stage present sufficient data to work with, but it was found preferable to include also the divisional arrangement of columns 14 and 15 in order to maintain the same arrangement throughout and to preclude any ambiguity in the instructions. The values of (601), (602) and

(603) are merely the footings of these columns. To compute the entries for columns 17, 18 and 19, use must be made of Table C of Step 7. The figures in columns 1, 2 and 5 of this table will be recognized as being those contained in the columns of like number of Table IV, being the constant percentages of distribution of the heating and lighting loads. The figures in columns 11, 12 and 13 are likewise in the similarly numbered columns of Table V, Feb. 15 issue, being the factors that were worked up for computing distribution of power. It will be recollected that these factors were constructed in such a way that using them to multiply the departmental man-hours for the month would give

STEP 8. Add columns 14 to 21, inclusive, and column 24.

(601) is the sum of the entries in column 14.
(602) " " " " " " " " 15.
(603) " " " " " " " " 16.
(604) " " " " " " " " 17.
(605) " " " " " " " " 18.
(606) " " " " " " " " 19.
The sum of the entries in column 20 should be equal to R.
" " " " " " " 21 " " " " S.
" " " " " " " 24 " " " " V.

STEP 9.

Compute the values of the entries to be made in columns 22, 23 and 25 of Table B in the following manner:

To determine the entries in column 22, multiply the corresponding entries in column 17 by $\frac{T}{(604)}$.

To determine the entries in column 23, multiply the corresponding entries in column 18 by $\frac{U}{(605)}$.

To determine the entries in column 25, multiply the corresponding entries in column 19 by $\frac{W}{(606)}$.

STEP 10.

Add columns 22, 23 and 25.
The sum of the entries in column 22 should be equal to T.
" " " " " " " 23 " " " " U.
" " " " " " " 25 " " " " W.

STEP 11.

Compile a monthly statement as in Table D following.

The values in column 26 are the same as those in column 20 or 21 of Table B. During the months in which buildings are not heated there will be no entries in column 26 owing to the fact that there will be none in columns 20 or 21, since R and S will of course be zero.

The values in column 27 are the same as those in column 22 or 23 of Table B, except (701), (702) and (703), which are computed as follows:

(701) = (607) + I
(702) = (608) + J

FIG. 6. STEPS 8, 9, 10 AND 11

the theoretical power consumption for each department, from which the actual departmental costs were to be obtained by dividing the total cost in the same ratios as the individual theoretical consumptions bore to one another. That is, each departmental cost would be made to be the same proportion of the total cost as each power consumption was of the sum of all the individual consumptions. To get the theoretical consumptions the values in column 14 must be multiplied by the factors devised for steam power from Battery No. 1, namely those in column 11. Similarly the steam loads on Battery No. 2 are represented by the products of the figures in columns 15 and 12, and the electrical loads by those of columns 16 and 13. The values so obtained are entered in columns 17, 18 and 19, respectively. It is to be observed, as already pointed out, that the values as computed do not really give the theoretical amount of steam or electricity used in terms of pounds or kilowatt-hours, or any other unit, because the factors used were worked up from percentages; but they do bear the same relation to one another as would the entries if expressed in usual units, and since the problem is to distribute the actual known cost in the same proportions as the theoretical power, it is immaterial whether this cost is distributed through the agency of figures given in pounds and kilowatt-hours, or whether it is done by means of arbitrary numbers, as long as the latter bear the same ratios to one another as would the pounds or other units.

Columns 20 and 21 serve for entering the distribution of the heating loads on Batteries No. 1 and No. 2, respectively. Multiplying R by the percentages in column 1, and S by those in column 2, effects this distribution. In like manner, the total cost of lighting, V, is distributed in column 24 according to the percentages in column 5.

The power distributions for Battery No. 1, Battery No. 2, and the electrical, are made in columns 22, 23 and 25, respectively. Before the distributions can be made columns 17, 18 and 19 must be added, the totals being represented by symbols (604), (605) and (606) as stated in Step 8. Columns 14, 15 and 16 should also be added, a check on the entries being obtained by comparing (603) with the sum of (601) and (602).

STEP 11 (continued)

The values in column 28 are the same as those in column 24 of Table B.
The values in column 29 are the same as those in column 25 of Table B.
The values in column 30 are the sum of those in columns 26 and 28.
The values in column 31 are the sum of those in columns 27 and 29.
The values in column 32 are the sum of those in columns 30 and 31.
The total of column 32 should be equal to (512) in Table A.

TABLE D
DISTRIBUTION OF POWER COST
FOR MONTH OF ..... 19...

DEPT.	STEAM		CURRENT		HEATING AND LIGHTING	POWER	TOTAL
	HEATING	POWER	LIGHTING	POWER			
	COL. 26	COL. 27	COL. 28	COL. 29	COL. 30	COL. 31	COL. 32
A							
B		(701)					
C		(702)					
D							
E							
F							
G		(703)					
H							
I							
J							
K							
L							
Misc.							
Total							

FIG. 7. STEP 11 (CONTINUED)

Columns 20 and 21 also are to be added to make sure that they sum up to the values of R and S already entered, thus checking the accuracy of this part of the work.

STEP 9. ACTUAL DISTRIBUTION OF POWER COSTS

STEP 9 is devoted to the actual distribution of power costs. As already stated, the totals T, U and W must be divided in the same proportions as are the totals (604), (605) and (606), respectively. Thus, column 17 contains the ratios giving the theoretical steam power entering the corresponding actual costs as figured from

the total T at the foot of the column. Assuming for the loads on Battery No. 1, and column 22 is reserved for sake of illustration that x represents the entry in column 17 opposite Department B, for example, then the following proportion would obtain, namely, (607) : T = x : (604), from which it is evident that (607) = (T × x) ÷ (604), or, writing it slightly differently, (607) = x × T ÷ (604). That is, the entries for column 22 are found by multiplying the corresponding ones in column 17 by the constant fraction T ÷ (604), which is the method contained in the instruction of Step 9. By a similar analysis the expressions for columns 23 and 25 are arrived at, column 23 containing the distribution of steam power load on Battery No. 2, and column 25 that of the electrical power.

After having made all the computations the entries in the three columns are to be added as directed in Step 10. As a check that the work was done correctly, the totals will have to agree with the values of T, U and W already entered.

For purposes of permanent record, the results of the completed distribution were summarized in tabular form as indicated in Table D of Step 11. For the most part, the procedure is self-explanatory. Only as regards entries (701), (702) and (703) is there need of any explanation. It has probably been observed that the values of I, J and K have so far nowhere entered into the distribution of costs. If the sum of all the costs appearing in Table B, namely R, S, T, U. V and W, were to be obtained, it would be found to be equal only to (509)+(510)+(511) of Table A, and not to the total expense (512). That is, I, J and K would be lacking, a fact referred to in discussing Step 5. It is therefore necessary to introduce these amounts before completing the distribution. As previously described, it was decided to consider all the labor of the subsidiary power units as being chargeable to the departments served by the unit, irrespective of any part of it which should, theoretically, apply to electrical generation. Consequently it was permissible to exclude these amounts from the calculations until the distribution of the remainder of the expense had been effected, after which they could be added in. Thus, I would be added to the total of the distribution found for Dept. B, J to that for Dept. C, and K to that for Dept. G. This is the procedure called for in the instructions in Step 11 relating to column 27. The figures which it was set out to find, namely, the power expense to be charged to each department for the period, are, of course, those that appear in column 32. A check of the entire work is obtained through the fact that the total of column 32 must agree with the amount represented by (512) in Table A.

Conclusion

The method herein described is necessarily one which gives only an approximation of the distribution desired. Outside of the disadvantages inherent to it under the best of conditions, there is another which it is of importance to recognize, and that is, that any change or addition in equipment will require a resurvey and corresponding correction of factors. However, in the case cited, it served its purpose very well. It was possible to prepare the figures and instructions in about 10 days' time, to have them ready for the then current month's distribution, and at a nominal expenditure, as contrasted with the outlay and particularly the delay which the installation of meters would have entailed. As regards the actual work involved in making the computations every month, one should not be misled by its apparent complexity as to the time required for its execution. By simply following the instructions by rote, and making use of the mechanical calculating devices at hand in the office, it was found that the entire procedure constituted about half a day's work for one man.

Oil Fuel Tests of Boilers Built for Wood Ships

Abstract of Paper Delivered at Annual Meeting of the American Society of Mechanical Engineers by F. W. Dean

IN CONSEQUENCE of the introduction of oil for fuel on many of the steamships belonging to the United States Shipping Board it became desirable to ascertain the relative merits of several of the mechanical atomizing oil burners for boilers. The tests were made under the direction of the writer assisted by Henry Kreisinger, then fuel engineer of the Bureau of Mines, and under the critical observation of Lieut.-Commander W. R. Purnell and Lieutenant Pennycook from the Philadelphia Fuel Oil Testing Plant of the U. S. Navy.

The boiler tested was the four-pass boiler illustrated in Fig. 1. In the oil tests the bottom of the casing was dropped 12 in. and the furnace on sides and bottom was lined with brickwork about 12 in. thick, with 2½ in. of sil-o-cel brick next to the casing. These were covered by 2½ in. of calcined brick. The sides were still further lined with firebrick 6 in. thick and the bottom covered with two courses of standard firebrick laid flat. This formed a very effective insulation, so good, in fact, that the bricks suffered accordingly. However, it was the standard lining of the Emergency Fleet and was very satisfactory in keeping down the temperature of the fire rooms aboard ship, for which purpose it was adopted. This is shown in Fig. 2.

The furnace volume was very small, the distance between the front and back walls was only 6 ft., and the distance from the back wall to the burner tip about 6 ft. 9 in. This short distance, without doubt, prevented the atomizing capacities of the burners from being fully developed. After every series of tests the joints between the bricks opposite each burner required pointing and sometimes the bricks over a small area required replacing.

The following were the dimensions of the firebox below the tubes:

Height of furnace at front	5 ft. ½ in.
Height of furnace at back	6 ft. 9 in.
Width of furnace	11 ft. 6½ in.
Distance between front and back walls	6 ft. 0 in.
Volume of furnace	408 cu. ft.

The boiler was equipped with thermocouples for

measuring the temperatures of the gases throughout the passes and in the uptake. At the latter level there were several thermocouples for determining the temperatures at various points, for it had been previously ascertained that the temperatures in the different parts of one horizontal plane of the uptake were not uniform and varied as much as 100 deg. F.

Means were provided for sampling the gases at various points throughout the boiler between the vicinity of the burners and the uptake. Thus the progression of the process of combustion could be ascertained. Similarly draft gages were arranged to indicate the drafts at various points.

The Oil

Mexican oil was used because it is the only oil that is usually available for steamship fuel. This oil as it comes from the wells is of about 21 gravity Baume.

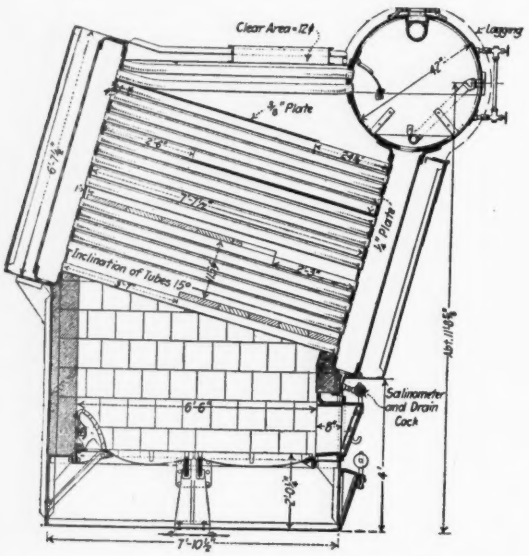


FIG. 1. FOUR-PASS STANDARD WATER-TUBE MARINE BOILER FOR WOOD SHIPS

About 12 to 13 per cent of gasoline is removed, leaving the oil at about 16 gravity Baume. The heating value per pound is about 18,330 B.t.u.

The Burners

As stated before, all burners tested were mechanical atomizing. This type is used at sea in order that all steam used in heating the oil may be condensed and saved for feed water.

Six kinds of burners were used, No. 1 being the U. S. Navy Bureau (of Steam Engineering) Standard Register Burner.

The oil was supplied to the burners by either of two horizontal duplex pumps, 5½ by 3½ by 5 in. A pair of suction and a pair of discharge oil strainers and an oil heater were loaned by the Schutte & Koerting Co. On the discharge pipe of the oil pumps there was a 6-in. chamber about 8 ft. high, which maintained the oil pressure at the burners sufficiently steady for the best results. This chamber was emptied of oil at the beginning of each test and charged with air at 100 lb. pressure.

The Navy Bureau Standard Burner

This burner is shown in Fig. 3 and consists of a circular cast-iron register with inclined (not radial) blades around the outside between two thin narrow rings with which they are cast, so formed that the air passes between them somewhat toward the center of the burner, and by them is given rotation.

The register is suitably bolted to the boiler front, but between it and the front there is a conical ring

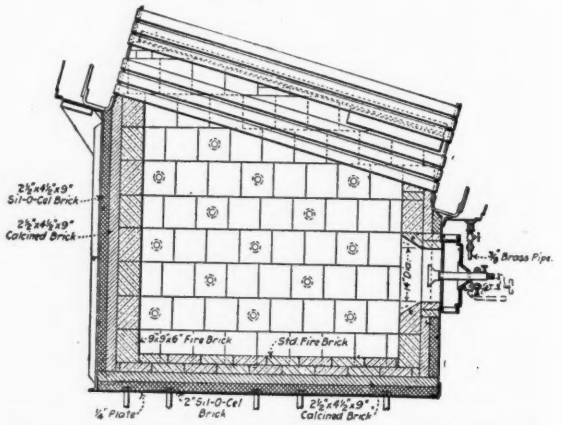


FIG. 2. ARRANGEMENT OF FURNACE IN BOILER FOR OIL FIRING

which serves to direct the air toward the oil and counteract the opposite tendency caused by the centrifugal effect of the register.

The oil is forced through a pipe to the so-called tip, which is screwed on the pipe and serves the purpose of delivering the oil to the furnace in a rapidly rotating stream passing through a very small hole. The tip consists of two hardened steel parts, the outer one being called the "nut," and apparent on the drawing. The nut has a conical cavity with the apex toward the furnace and the other part is conical and fits it in firm

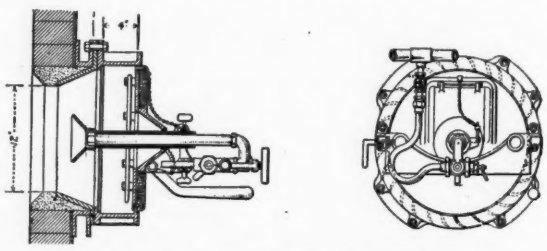


FIG. 3. THE NAVY STANDARD BURNER

contact. The latter is provided with tangential grooves fed by small holes and these grooves serve to rotate the oil as above mentioned.

The centrifugal force derived from the rotation of the oil causes the latter to spread into the form of a thin hollow cone, which is protected from the inrushing air from the register by a cast-iron cone until it reaches an advisable thinness at the edge of the cone, where it is met by the rotating air with which it is thoroughly mixed. Immediately beyond this line of

mixture the ignition occurs and the completeness of combustion depends upon the adequacy of the quantity of air, the completeness of the atomization of the oil, and the thoroughness of the mixing.

The other burners have tips that rotate the oil, as this is indispensable in thinning the oil film, but burner No. 4 rotates the air but little, and No. 6 not at all. This demonstrates that the rotation of the air is not necessary, a conclusion that might otherwise have been reached.

The Tests

Four burners of each kind were applied to the boiler, and, except the Navy Bureau Standard burner, were placed with their centers 30 in. apart and 20 in. above the furnace floor, leaving 24 in. between the side walls of the furnace and centers of the adjacent burners. In some of the tests the bureau burners were arranged likewise, but at the beginning they were placed with their centers 36 in. apart and 22 in. above the furnace floor, leaving 15 in. between the side-burner centers and the walls. No advantage in either spacing could be discerned.

The first burner to be used was the Bureau, and on account of inexperience with Mexican oil very poor results were for some time obtained and immense amounts of smoke made. With more experience excellent results were obtained and there was no difficulty

RESULTS OF EVAPORATIVE TESTS OF BOILER EQUIPPED WITH FOUR NO. 1 BURNERS

Fuel Oil Used: Mexican Petroleum Residuum

1	Test number	37	33	29	38	31	36
2	Date of trial, 1919	Aug. 8	Aug. 1	Jul. 26	Aug.9	Jul. 31	Aug. 7
3	Duration of trial, hr.	7 4	6	8	4 88	7	5
4	Barometer, in.	29 4	29 3	29 5		29 5	29 14
5	Number of burners used	4	4	4	4	4	4
	DIMENSIONS AND PROPORTIONS						
6	Furnace volume, cu. ft.	408	408	408	408	408	408
7	Heating surface, sq. ft.	2518	2518	2518	2518	2518	2518
8	Ratio of h.s. to f.v.	6 13	6 13	6 13	6 13	6 13	6 13
	AVERAGE PRESSURES						
9	Steam pressure by gage, lb.	200 2	197 0	203 1	196.7	193 60	201 0
10	Atmospheric pressure, lb.	14 46	14 26	14 51		14 51	14 34
11	Absolute pressure, lb.	214 66	211.26	217 61		208 11	215 34
12	Draft between damper and boiler, in.	0 382	0 774	0 947	1 475	1 902	2 51
	AVERAGE TEMPERATURES						
13	External air, deg. fahr.	72 8	74 6	82 8	70 6	74 6	86 2
14	Fire room, deg. fahr.	74 7	83 6	89 8	79 2	84 9	92 7
15	Feedwater, deg. fahr.	116	90	68.6	85 9	73 7	91 7
16	Escaping gas, deg. fahr.	414	412	465	516	538	583
17	Furnace by optical pyrometer, deg. fahr.	2198	2230	2331		2551	2654
	FUEL DATA						
18	Oil consumed per hour, lb.	527	615 5	797 8	1137 8	1341 0	1584 6
19	Oil per hour per sq. ft. heating surf., lb.	0 211	0 246	0 325	0 455	0 537	0 634
20	Oil per hour per cu. ft. of fur. vol., lb.	1.292	1 509	1 98	2 79	3 29	3 882
21	Oil per hour per burner, lb.	131 8	153 9	201 95	284	335 3	396.2
22	Temperature of oil at burners, deg. fahr.	266	264 1	276 5	283 4	260	281
23	Pressure of oil at burners, lb.	146.2	181.9	249 3	167 8	228	236 4
24	Heat value per pound of oil, B.t.u.	18376	18376	18352	18376	18376	18376
25	Moisture in oil, per cent	0 15	0 15	0 05	0 15	0 15	0 15
26	Silt, per cent	0 00	0 00	0 00	0 00	0 00	0 00
27	Specific gravity at 60 deg. fahr.	0 962	0 962	0 96	15° C., 0 962	0 962	0 962
28	Viscosity, deg. Engler at 65.5 deg. cent.	20 39	20 39		20 39		20 39
29	Flash temperature, deg. fahr.	167	167	158	167	167	167
30	Burning temperature, deg. fahr	270	270	266	270	270	270
31	Carbon, per cent	84 02	84 02	84 19	84 02	84 02	84 02
32	Hydrogen, per cent	11 00	11 00	11 11	11 00	11 00	11 00
33	Sulphur, per cent	4 04	4 04	4 07	4 04	4 04	4 04
34	Gravity at 60 deg. fahr., Baumé scale	15 50	15 50	15 80	15 33	15 54	15 54
	QUALITY OF STEAM						
35	Moisture in steam, per cent	1 11	1 04	0 91	0 85	0 87	0 93
	EFFICIENCY						
36	Efficiency of boiler and furnace, per cent	75 9	77 7	76 8	78 9	77 0	76 1
	WATER AND EVAPORATION						
37	Water supplied to boiler per hour, lb	6663	7783	9876	14520	16555	19620
38	Dry steam generated per hour, lb.	6590	7700	9790	14397	16400	19437
39	Factor of evaporation	1 150	1 176	1 198	1 180	1 192	1 174
40	Evap. per hour from and at 212° fahr., lb.	7580	9060	11730	16988	19550	22819
41	Do. per sq. ft. heating surface, lb.	3 03	3 62	4 69	6 80	7 82	9 14
42	Actual evaporation per lb. of oil, lb	12 50	12 51	12 12	12 65	12 22	12 27
43	Equivalent from and at 212° fahr., lb	14 38	14 72	14 53	14 93	14 57	14 40
44	Do. per cu. ft. of furnace volume, lb	18 57	22 20	24 00	41 63	47 93	55 95
	POWER OF BOILER						
45	Land hp. obtained (rated at 250 hp.)	220	263	340	492	567	661
46	Per cent of land rating obtained	88	104	136	197	227	265
47	Equiv. land hp. of marine rating	435	435	435	435	435	435
48	Per cent of marine rating obtained	51	60	78	113	130	152

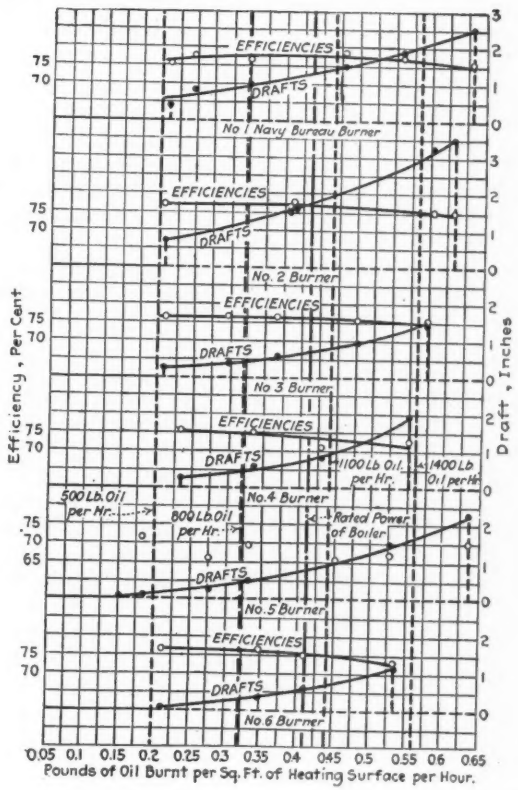


FIG. 4. EFFICIENCIES AND DRAFTS OF SELECTED TESTS

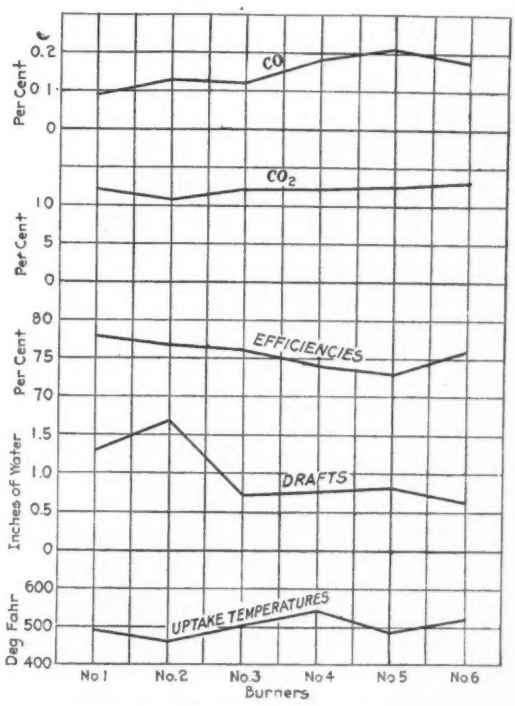


FIG. 5. COMPARISON OF BOILER EFFICIENCIES, DRAFTS, CO_2 AND UPTAKE TEMPERATURES AT RATED POWER OF BOILER WITH DIFFERENT BURNERS AND AVERAGE CO_2 OF SELECTED TESTS

in preventing smoke with this or any burner. In general a slight amount of smoke was allowed. At the beginning there was frequent difficulty from the carbonizing of the oil, but this was gradually overcome.

The criteria by which the merits of a burner can be judged when used with induced draft are its ability to burn the oil to CO_2, to do this with a minimum of draft, to produce little smoke, to produce no carbonization in the burner, and to have sufficient range in oil-burning capacity.

To produce desirable CO_2 the oil atomization must be well performed and the air admitted in such a manner that it will intimately mix with the oil.

Results of the Tests

The results of the tests which are considered to be most reliable and to represent the merits of the burners are given in four tables in the complete paper, of which the table shown herewith is representative.

It was intended with each kind of burner to consume oil at four different hourly rates for four burners collectively, namely, 500 lb., 800 lb., 1100 lb. and 1400 lb., but it was impossible to realize these results with precision.

In judging the merits of a burner by the magnitude of the CO_2 and CO, a difficulty is encountered from the fact that these constituents are not uniformly distributed throughout the area in which they are determined, whether it is in the uptake or in one of the passes.

Usually, in the boiler tested, the combustion is complete by the time the gases reach the first or lowest pass of the boiler, but if the gases are sampled in this pass they are far from uniform at different points between the end of the baffle and rear header.

This variation of the gases of combustion renders it difficult to apply the chemical criterion in determining merits of a burner. In operating burners, of course, constant studies of the gas analyses are made, and this is necessary, for if the CO_2 is good at one point it is probable that it is at others. Nevertheless, it is necessary to determine the efficiency of the boiler under the same conditions as a final means of judging of the performance of a burner. It may be found that the maximum boiler efficiency will not correspond with the maximum CO_2 and this is true with these tests.

In Fig. 4 the efficiencies and drafts of the various burners are plotted. The Bureau Standard burner required more draft than the others. The reason for this is that it was designed for use on war vessels and made to require a strong draft, or fire-room pressure, in order not to backfire from gun shock.

In Fig. 5 a diagram of comparative uptake temperatures, drafts, efficiencies, CO_2 and CO is given.

Burner No. 6 required the least draft and the least adjusting. It was the only burner that did not vibrate; it gave the highest CO_2 but also next to the highest CO. All other burners required constant adjusting to maintain proper CO_2, and the reason for this could not be ascertained.

Semi-Diesel Engine Operation

Cooling of Heads; Fitting and Lubricating Bearings; Effect of Temperature and Compression on Efficiency; Cylinder Gaskets to Prevent Water Leakage. By F. C. De Weese*

OIL ENGINES of the Semi-Diesel type, unless carefully handled, and kept in proper repair, may be a source of much trouble and annoyance, but when properly cared for should give no more trouble than a steam engine of the same capacity; but it has been the experience of the writer that, if it is desired to maintain uninterrupted service with the semi-Deisel engine, good reliable men, who have a reasonable amount of knowledge of the theory of operation of this type of engine, should be employed as there *is* something to do besides opening the throttle, give her a little lubrication and watch her run.

With oil engines the greatest trouble is usually experienced from the heads becoming overheated, from an insufficient cooling water supply, from turning the water into the heads after they have been heated, from overload, or from scale. One of the most important things, and one that an operator should always be sure of, is to see that the heads are full of water before lighting the burners, and also to be sure that this water has no chance to leak out while the heads are being heated preparatory to starting. But, in case the water should leak out and it is discovered, even though you think the heads are not hot enough to cause them to crack when the water is turned in, do not under any circumstances make the mistake of turning the water into the cylinders. Turn out the burners, and allow the heads to cool down to a temperature where you are sure it is not dangerous to have the water enter them.

The newer type of engines, having the cooling water entering the head instead of at the bottom of the cylinders, is much to be preferred, for one reason because it requires less cooling water, but mainly for the reason (this refers to the vertical engine) that cylinder jacket is at the same temperature, and this materially reduces strains set up in the castings due to uneven temperatures. In this connection it may be said that it is preferable to have the water entering the cylinder at around 70 deg. F. rather than to have it colder. This calls, of course, for a larger volume of water, but it also reduces the strains in the cylinder walls due to unequal expansion and contraction.

Bearings

Bearings are something that must be looked after carefully, and this is where a good mechanic comes in handy. It requires a good babbit metal to stand up in the crank bearings, and in fitting crank bearings great care should be exercised to see that they are not left with too much clearance. A loose crank will soon pound out the metal in the bearings, and there is no chance to save a crank bearing once it begins to heat, as the crank case being inclosed, the heat cannot be detected in time to save the bearing.

*General Superintendent, Eastern Minnesota Power Co.

In fitting crank bearings the mistake is often made of scraping the top half of the bearing too much, not giving a thought to the effect that this will have on the compression, or sometimes the bearing will not be bored true, that is, not centered exactly, the consequence being that one-half has thinner metal than the other, no attention being paid to this fact when fitting the liners to the crank. A good way to fit the liners is to have the clearance between the cylinder head and the piston just enough so the piston will not strike the head, when the head has no gasket under it; there should be supplied for the crank bearings a number of very thin shims, to be used for adjusting. Give the engine a short run, shut her down and make the final adjustment, and it should be so that you can just feel the slightest movement of the shaft in the bearing. Usually, if the engine will turn over freely, the bearing is not too tight.

Lubrication

Nothing but a good grade of lubricating oil should be used and the oil that will give the best results from the standpoint of operation should always be used. It is usually safe to follow the recommendation of the manufacturer of the engine as to the best make of lubricating oil to use, but I do not advise following this advice in every case; for I have known cases where lubricating oil was used not according to the advice of the manufacturer, and much better results obtained. This is where a high grade man is of exceptional value, as he does not have to take the word of everybody who comes along, but is the best judge as to what gives the best results. All lubricating oil fed to the engine should be strained through a strainer not coarser than 30 mesh.

Timing

Usually it is safe to follow instructions of the manufacturer as to the correct timing for fuel injection, but I have in mind a case where the engine was timed according to instructions, yet it would not operate satisfactorily, and by checking the matter it was found that the injection cam was worn back so far that the point of the high cam was about ¼ in. late, thus causing the fuel to be injected that much late; by shifting the marks used for setting ¼ in. ahead the timing was correct and the operation much improved.

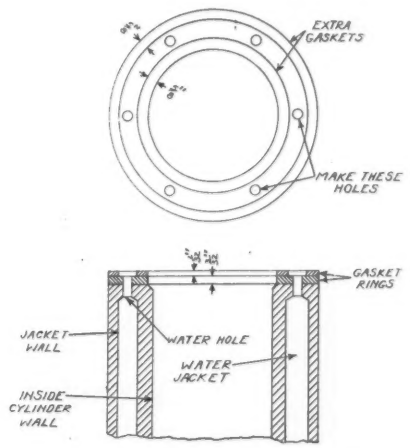
Temperatures

It is impossible to lay down any hard and fast rules to be followed, as there are so many variable conditions that each case must be governed by the local conditions. Of course the higher the temperature, within reasonable limits, the higher the efficiency of operation. If the compression is low, when operating at light load, the temperature must be carried high; otherwise the firing will not be regular and sometimes one side or one cylinder will possibly not be firing at all, with the result that the fuel oil will run out into the exhaust pit and eventually explode. I have known concrete exhaust pits to be cracked badly from explosions caused by the fuel oil running out through the exhaust pipe and into the pit. Exhaust pits should be burned out about once a week, and this should be done while the engine is in operation, and can be very easily ignited by lighting a piece of oily waste and dropping it in the manhole.

But getting back to the operating temperature, I have found a good range to be from about 140 deg. to about 190 deg. F. Of course, it is not good policy to let the temperature run as high as 190 deg., unless you have absolute control of the cooling water, and a goodly supply. When the engine is started, the temperature should be run up reasonably high and as the load comes on it should be gradually reduced to about 140 deg. Some engineers advocate about 120 deg. at full load, but it has been my experience that the operation will be much more satisfactory at about 140 or 150 deg.

Cylinder Head Gaskets

It is a source of great annoyance to have to contend with a leaky gasket, and also a source of danger, if the water is leaking on the inside, for any great quantity of water is liable to be the cause of cracked cylinder



ARRANGEMENT OF THIN EXTRA CYLINDER HEAD GASKETS FOR PREVENTING WATER LEAKAGE

heads. I have found that a good way to prevent leaking between the cylinders and heads is to use a good grade of long fiber asbestos, about 3/32 in. thick for the main gasket; then cut a ring of asbestos of about 1/32 in. thickness, place a ring of this about ⅝ in. wide on top of the main gasket, one around the inside and one around the outside, with all water openings between these two rings. This is shown in the accompanying illustration.

If the head happens to be of two-piece construction, one piece the main cylinder head and the other a combustion head, with three holes in the top head for water circulation, cut three rings for the top head with a hole in the center of each the same size as the hole in the head, and an outside diameter of about 3 in., placing these on top of the other gasket. By the use of these rings of thin asbestos, a greater pressure may be had around the water holes than it is possible to obtain otherwise.

Before putting the heads in place it is good policy to use some cylinder oil and graphite, applied to the gaskets with a paint brush; then draw the heads down good and tight; give the engine a run, long enough to warm it up to about normal operating temperature; stop the engine and again draw the heads down. If this procedure is followed, I can assure anybody that his troubles, due to leaky gaskets, will be small.

Often it is the case that an oil engine will not carry

the load that it was designed to handle. As a rule this happens after long years of service and abuse, and in many instances, the operator or owner places the blame on the builder, when, if they will look into the matter, they will find themselves to blame for allowing the engine to get into that condition.

As an illustration of the above, I am submitting as a part of this paper, in substance, a report which I made to the owners of a 100-hp. vertical, semi-Diesel oil engine, which would not handle the load that was expected of it.

"Please accept this as my report on the condition of your . . . oil engine, at this place.

"During the month of July, this year, the total generated output was found to be 6600 kw.-hr., and the number of hours the engine was operated was 389.5, making an average load of 17 kw., which is approximately 19 per cent rated capacity of the engine. The capacity of the engine is about 90 hp. at this elevation, which is 3500 ft. This makes an allowance for a decrease in capacity of about 3 per cent per 1000 ft. of elevation.

"Fuel oil consumption was 1620 gal., or approximately 12,150 lb. Assuming the fuel oil to contain 18,000 B.t.u. per pound, which is probably low, the total B.t.u. for the month would be 219,700,000, and the total B.t.u. equivalent of electricity at the switchboard was 22,519,000, which is approximately 33,000 B.t.u. per kw.-hr., or, 1.47 lb. fuel oil per kw.-hr., and an over-all thermal efficiency of 10.3 per cent. As this is a direct-connected unit, and as the generator efficiency is shown by the curve to be about 80 per cent, the brake thermal efficiency of the engine is shown to be 12.36 per cent.

"The cause for the high fuel consumption and low thermal efficiency may be summed up as follows:

"Compression in the No. 1 cylinder as shown by the indicator was 180 lb. gage, and in the No. 2 cylinder 192 lb. gage. This low compression is primarily due to leaky air stop rings, which, of course, cannot be remedied without being able to shut the engine down for an indefinite length of time, re-surfacing the rings and castings and inserting new springs behind the air stop rings. The air leaks out through the main bearings, joints between the castings, and various other places, thus greatly reducing compression in the crank cases which, in turn, reduces the pressure that would otherwise be admitted to the cylinders, and this prevents the high compression that should be obtained and also prevents proper scavenging. A part of the loss of compression is due to the bearings being worn, especially the crank bearings, as any wear of the bearings lowers the pistons, increases the clearance volume and decreases the compression. The piston rings are in good shape and there is practically no leakage past them.

"As nearly as I am able to determine the clearance of this make of engine, when new, is approximately 10 per cent. With a clearance of 10 per cent the ratio of volumes would be 9 to 1 and the ratio of pressures will be 16.7 to 1.

"The atmospheric pressure at 3500 ft. elevation is approximately 13 lb. per sq. in., and as I did not have a spring low enough to measure the pressure in the crankcase, I will assume that the compression there is 1 lb. per sq. in. This would make the air enter the cylinder at 14 lb. absolute. The pressure at end of stroke will be $14 \times 16.7 = 235$ lb. absolute, or 222 lb. gage.

"It will be seen from the above that the compression does not follow a straight line, but decreases rapidly with an increase in clearance volume.

"As the No. 1 cylinder has 180 lb. compression and No. 2 cylinder 192 lb., the average compression is 186 lb. This makes compression approximately 15 per cent lower than it should be and, as the power of an engine is directly proportional to the compression pressure, the horsepower is reduced to 76.5."

The foregoing is offered with the hope that it will be of benefit to those who are having trouble; but there are some who are trying to get away with an overload on their oil engines, and it has been the experience of the writer that this should not be done, if it is possible to avoid it. There is also the item of "Altitude Factor," which should always be taken into consideration when load conditions are considered, and an allowance made of 3 per cent decrease in rated capacity for each 1000 ft. in elevation above sea level.

A CENSUS OF all persons engaged in any form of industrial or public safety work, and industrial health work, is being taken by the National Safety Council. This is the first time that any attempt has ever been made to list all the persons whose profession is the saving of lives and limbs and the promotion of good health among workers.

Every industry and every section of the country will be covered in the census. The census will include not only members and employes of members of the National Safety Council, but also all persons professionally engaged in safety and industrial health activities and not connected with the council in any way.

Every reader of this publication who is professionally engaged in industrial or public accident or industrial health work—whether he is devoting all or only part of his time to accident prevention—is urged to assist in the taking of this census by sending his name and suitable data regarding his position, work, etc., to the National Safety Council, 168 North Michigan Ave., Chicago.

INDICATIONS are numerous that the coming year will bring a considerable betterment in the condition of the power plant industry. The water power act is beginning to function, power load is increasing in many instances, money is coming to a more reasonable cost for construction work and the price of power equipment and building materials is decreasing. Some important work is being placed under contract.

Dwight P. Robinson & Co. has a contract for the installation of the second 60,000-kw. unit at the Colfax Power Station, and for three additional substations along the lines of the Duquesne Light Co. in the Pittsburgh District. The New Orleans Railway and Light Co. is proceeding with extensive additions to its power plant and distributing systems, including the installation of a 20,000-kw. turbine and auxiliaries.

Preliminary engineering work on several large developments and reports on other prospects which are being prepared by Dwight P. Robinson & Co. indicate that public utilities in many parts of the country are contemplating a renewal of construction activity.

Power Plant of the New French Liner "Paris"

TURBINE DRIVEN AND WITH OIL-FIRED BOILERS, DELIVERING 46,000 HP. WITH 10 MEN IN THE STOKEHOLD

ONE OF the latest and handsomest of the ships in Trans-Atlantic traffic, the Paris, was recently put into service beween Havre and New York. She has a length over all of 764 ft. 6 in., moulded breadth of 85 ft. 4 in., depth from cabin deck to keel of 68 ft. 2 in., loaded draft, 31 ft. 2 in., cargo capacity of 123,600 cu. ft. and 10,093 T. burden. Above the cabin deck are a promenade deck and a deck for boats, making the total height above the keel 90 ft. 11 in.

All material used in the hull and internal structure is high tensile steel, great care having been given to design and construction at all points. Fourteen watertight bulkheads, extending up to the fifth and sixth decks, divide the hull into 15 compartments, the boiler room being thus divided into five compartments ensuring the isolation of the effects of leaks or fire.

Under the stokehold is a double bottom arranged for storage of oil fuel and divided into four compartments. These and compartments into which water might flow are connected to transfer pumps, so that liquids can be quickly moved from one side to the other to trim ship and prevent listing. All water-tight doors are operated from the bridge.

of berths. There are the drawing rooms, reading and smoking rooms, gymnasium and other conveniences usually found on a modern passenger palace, but decorations and furnishings are of unusual beauty and dining rooms are provided of capacity so that all passengers may be served at one time.

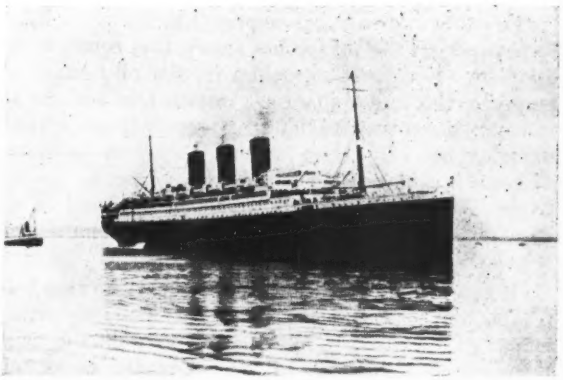


FIG. 5. THE PARIS LEAVING PORT

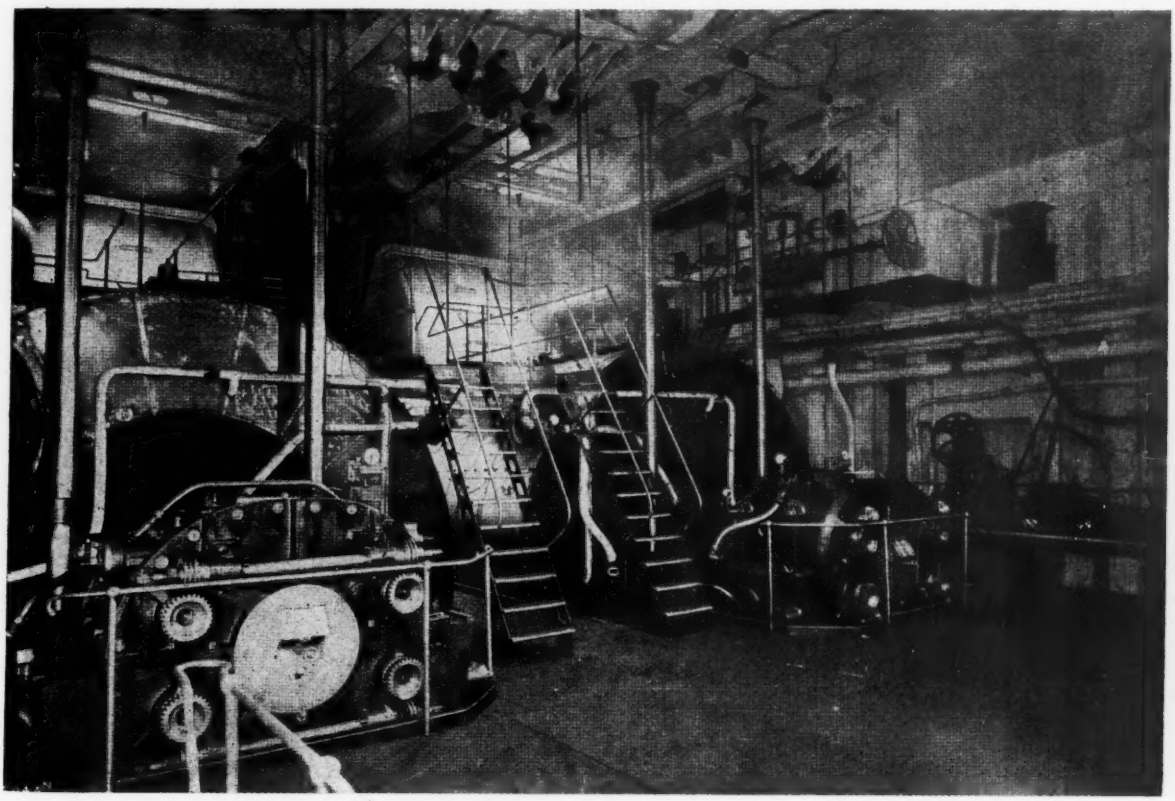


FIG. 1. MAIN TURBINE ROOM OF S.S. PARIS

CAPACITY

THE PARIS is arranged for 563 first-class, 460 second-class, 1092 third-class, and 1118 emigrant passengers, the finest of the cabins being fitted with bath room, having hot and cold water, and equipped with beds instead

Machinery is located in the hold of the ship, arranged as shown in Fig. 2. Each of the five stokeholds contains three double ended boilers, with oil fuel banks at the sides. Aft is the engine room with low-pressure turbines in the center and high and intermediate-pres-

sure turbines at the sides. Boilers are of marine return tubular type, each having four Morrison furnaces at each end. The boilers are 17 ft. 8½ in. diameter by 21 ft. 10¼ in. long with 97,600 sq. ft. heating surface and designed for 213 lb. pressure.

Oil Burning

Oil fuel is used exclusively, the Wallsend-Howden low-pressure system being employed as shown in Fig. 3. Experience on the voyage has shown that combustion is complete. For each stokehold a regular oil heating and pumping unit and a spare are installed, either one able to carry the entire load of that room. Heaters have a steaming out connection so that they can be cleaned without breaking any connections. Special vertical, triplex single-acting pumps, arranged for hand or electrical drive are provided to handle the oil until steam is raised in one boiler.

Figure 4 gives a view of one stokehold, showing boiler fronts, bulkhead and the cleanliness possible with oil firing. The 20 side tanks and 24 tanks in the double bottom have a capacity of 6160 tons, the tanks being fitted with heating coils so that viscous oils can be used regardless of outside temperature. Oil may be drawn direct to the heaters, or if necessary, passed to the settling tanks in the forward boiler room, thence to the heaters.

Main valves in the oil system can be operated hydraulically from the engine room near the engineers' quarters, or directly by hand. Only 10 men are required in the stokehold.

Turbine Units

These are connected to four screw-propellers, each low-pressure turbine driving one screw either ahead or astern, while the side screws are driven for ahead, one by the high-pressure, the other by the intermediate turbine, and for astern, each by a high-pressure turbine. Connections are arranged so that the intermediate turbine may be cut out, and the high-pressure exhaust to the low-pressure, or the high-pressure may be cut out and the intermediate take steam direct from the boiler. If both wing compartments are flooded, boiler steam may be admitted to the low-pressure turbines for either ahead or astern driving. The turbines are rated at 46,000 hp. and drive the ship at 22.5 knots at standard speed.

Two main condensers are located aft of the low-pressure turbines, each having 16,680 sq. ft. of cooling surface, and two circulating pumps with capacity of 158,900 cu. ft. per hr. at 450 r.p.m. Each condenser is divided into two parts, either of which may be isolated for inspection or repair keeping the other part in service. Each condenser is provided with an air pump to handle 140 T. of condensate an hour, and for emergency a set of rotary air pumps driven by a high-speed compound engine and two condenser pumps can handle 280 T. an hour.

Auxiliaries

For boiler feeding, two sets of three pumps each are installed in the central compartment, any two pumps being able to feed all 15 boilers at full speed. Two evaporation sets are placed in the side turbine compartments, each having two evaporators of 120 T. capacity

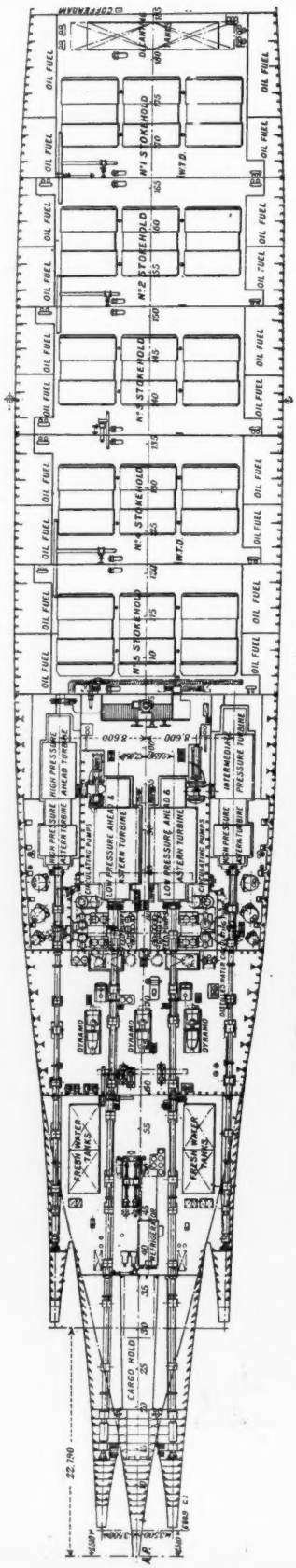


FIG. 2. PLAN OF HOLD AND ARRANGEMENT OF POWER PLANT

a day for the boilers and one of 60 T. capacity for general use.

Feed heaters are on the contra-flow principle, using the exhaust from the auxiliary machinery at 7 lb. and raising 280 T. of feed water an hour from 104 deg. F. to 194 deg. Any surplus of steam is taken to the condensers for auxiliary apparatus of which there are two abaft the turbine room, each with 2150 sq. ft. of surface, an air pump to handle 26,500 cu. ft. and a circulating pump to handle 200 T.

Three 450-kw. generators are driven by Rateau turbines which exhaust into the main low-pressure turbines when at sea, or into the auxiliary condensers when in port. For emergency work an oil engine is located on the upper deck, driving a generator to keep lights on the ship in case of accident, and supply current for electric winches to lower the boats and for the wireless apparatus.

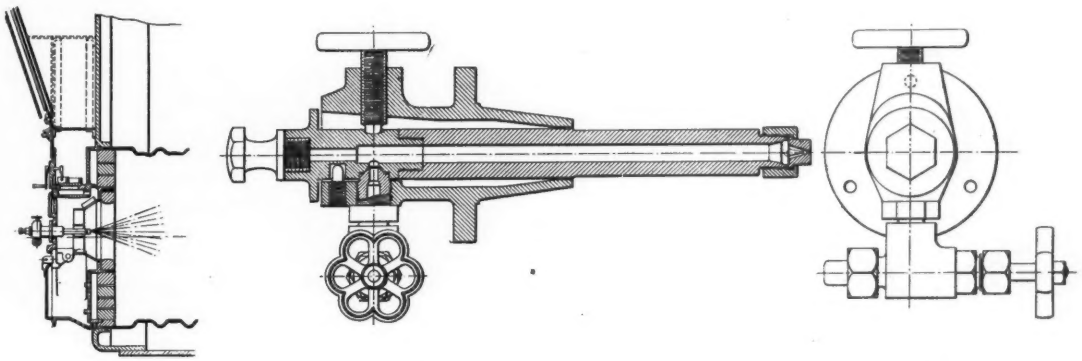


FIG. 3. ARRANGEMENT AND DETAILS OF OIL BURNING SYSTEM

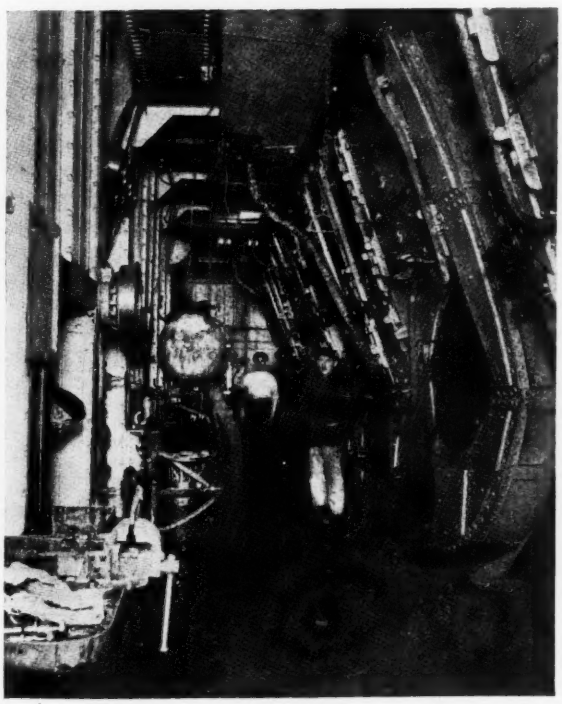


FIG. 4. STOKEHOLD SHOWING FRONTS OF OIL-FIRED BOILERS

An ammonia refrigerating plant cares for storage rooms for provisions, temperature of the rooms being indicated by long-distance thermometers in the engine room.

The Paris was built by the Penhoet works of the Societe des Chantier et Ateliers de St. Nazaire, and while not the largest of the Atlantic liners, it may safely be classed as one of the most perfect from the points of safety, comfort and completeness.

THE IRON ore mined in the United States in 1921, exclusive of that which contained more than 5.5 per cent of manganese, is estimated at 29,547,000 gross tons, a decrease of 56 per cent as compared with the output in 1920. The shipments of ore from the mines in 1921 are estimated at 27,009,000 gross tons, valued at $89,688,000, a decrease in quantity of 61 per cent and in value of nearly 69 per cent as compared with the shipments in 1920. The average value of the ore per gross ton at the mines for the whole United States in 1921 is estimated at $3.32; in 1920 at was $4.11. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently increased from 11,378,794 gross tons in 1920 to 13,872,000 tons in 1921, or 22 per cent. The output of iron ore in 1921 was the lowest since 1904, when 27,644,330 tons was mined.

U. S. CIVIL SERVICE COMMISSION announces examinations for Assistant Examiner, Patent Office, March 22, 23, and 24, to fill vacancies in the Patent Office, Washington, D. C., at the entrance salary of $1500 a year, with the bonus granted by Congress of $20 a month to appointees whose services are satisfactory, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Competitors will be rated on mathematics, physics, mechancial drawings, language, technics, and an optional subject from a given list. Applicants must have reached their twentieth but not their seventieth birthday on the date of the examination. In view of the retirement act, should the appointing officer so request, certification will not be made of eligibles who have reached their fifty-fifth birthday. Apply for Form 1312, stating the title of the examination desired, to the Civivl Service Commission, Washington, D. C.

The Ruths Steam Accumulator

STORING HEAT ENERGY FOR THE GENERATION OF LOW-PRESSURE STEAM TO REDUCE INSTALLED BOILER CAPACITY AND LEVEL UP PEAKS OF FUEL CONSUMPTION. BY J. H. BLAKEY

IN THE Genie Civil for Nov. 25, Mons. E. G. Constam-Gull describes the Ruths Steam Accumulator, which is giving satisfactory service in a number of Scandinavian plants.

The progress made during recent years in the better use of heat energy, for instance, in the utilization of the heat formerly lost in the gases from blast and coke furnaces, and in the exhaust steam from turbines, etc., has not been accompanied by corresponding improvements in the adaptation of the quantities of energy produced to the often very variable amounts used by heat motors of different types. Fluctuations in the demand for steam are generally met by more or less intensive firing, and the peak loads are taken care of by driving the boilers in a way which is detrimental to their maintenance and duration. The Swedish engineer, Ruths, whose patents are handled by the "Vaporackmulator" Society of Stockholm, has attempted to remedy this evil by means of the accumulation of heat in receivers which play the part of thermal flywheels, absorbing any excess and giving it out again when and as it is needed.

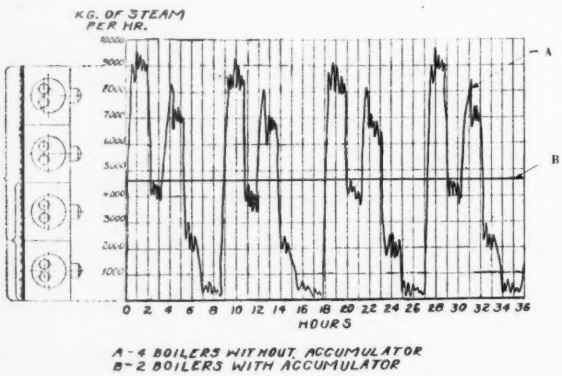


FIG. 1. CONSUMPTION WITH FOUR BOILERS ALONE, AND COMPENSATION FOR VARIATIONS BY MEANS OF AN ACCUMULATOR CUTTING OUT TWO BOILERS

This principle is, of course, not new, having been applied to turbines of the Rateau type and described in the technical journals about 18 yr. ago. The Swedish invention has proved very successful in adapting a constant boiler pressure to a fluctuating load, and is of particular value in thermo-electric installations. A regulator is arranged between boilers and motors; actuated both by high-pressure and low-pressure engines, it maintains a constant pressure in the boilers and regulates the low-pressure system. The steam for the latter is supplied by an accumulator which also furnishes steam for washing machines, baths, or the heating of buildings.

The compensation of fluctuations of boiler load is shown in Fig. 1. Four boilers were required to take care of the peak loads shown by line A; after the installation of an accumulator, two boilers maintained at constant pressure (line B) met all the demands made upon them, the accumulator giving up heat at times of peak load and receiving and storing it when the demand was lightest. In the majority of cases, it is a question of storing considerable quantities of steam, which it is not practical to accumulate in one boiler. As shown by Fig. 2, for a mean consumption of 19,360 lb. of steam per hour, and varying from 8800 to 30,800 lb., a study of the load diagram shows that the accumulator must have a capacity of 35,200 lb. of steam (surface A), whereas a boiler even with a large water surface has a much smaller capacity (surface B). In the latter case, a fall of pressure amounting to possibly 20 per cent must be allowed for. With an accumulator water-tube boilers can be used to advantage, and maintained at normal pressure.

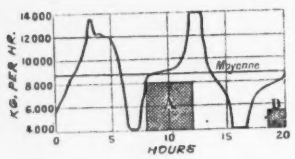


FIG. 2

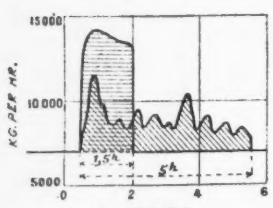


FIG. 4

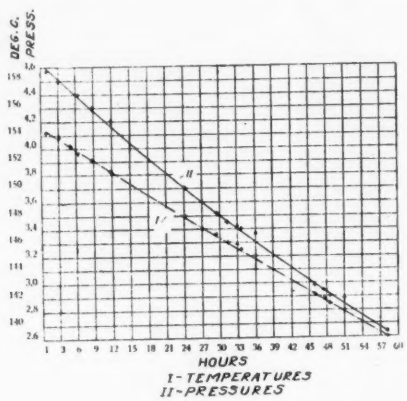


FIG. 3

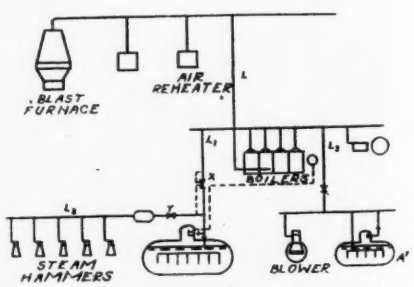


FIG. 5

FIG. 2. DIAGRAM OF THE CONSUMPTION OF STEAM IN A PLANT, COMPARING THE STORAGE CAPACITY OF AN ACCUMULATOR WITH THAT OF A BATTERY OF BOILERS. FIG. 3. FALL OF TEMPERATURE AND PRESSURE IN AN ACCUMULATOR WITH ADMISSION AND EXHAUST CLOSED. FIG. 4. DIARGAM SHOWING THE USE OF AN ACCUMULATOR IN SPEEDING UP A MANUFACTURING OPERATION. FIG. 5. DIAGRAM OF THE INSTALLATION AT THE IRONWORKS OF SANDVIKEN, SWEDEN, WITH TWO ACCUMULATORS

The accumulator is a cylindrical, horizontal reservoir with hemispherical ends, of soft steel boiler plate, one, for example, installed in 1920, being 64 ft. long, 16½ ft. diam., with a capacity of 1056 cu. ft. It is filled with water to about 95 per cent of its content. This absorbs or gives up steam according to the fluctuations of the demand, admission and discharge being regulated by valves in the steam pipes. The size of the accumulator depends, of course, upon conditions of boiler capacity, variations of load, etc., and with proper design the quantity of water will be such that its level scarcely varies, so that it requires little or no attention. On account of its large size, it is generally installed out of doors and is, therefore, covered with a heat insulator which in turn is protected by an outer covering of thin plate. In consequence of this careful insulation, and also because of the large amount of steam handled and the small proportion of radiating surface to the capacity, losses by cooling, even in the cold Scandinavian climate, seldom reach one per cent

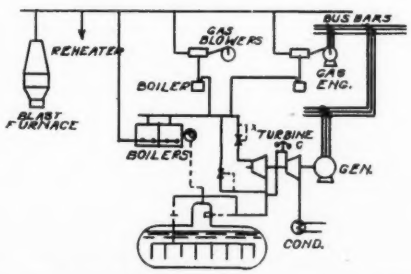


FIG. 6. DIAGRAM OF AN INSTALLATION AT AN IRONWORKS HAVING A DISTRIBUTION OF ELECTRICAL ENERGY

of the discharge from the boilers. Figure 3 shows a chart of these losses during a period of 60 hr., in a hermetically sealed accumulator.

According to returns from a large number of plants in Sweden, the average saving of fuel with an accumulator has been from 15 to 20 per cent. In addition, the boilers are kept at normal pressure, thus avoiding undue wear and strain, and any unexpected demand for steam is met without difficulty. As a consequence of regular running, the proportion of CO_2 in the smokestacks is quite even, varying between 14 and 15 per cent over a 5-hr. run, and in some cases the boiler efficiency has been not less than 85 per cent. In a sugar refinery before the installation of an accumulator, a certain operation required 5 hr. for its completion on account of the impossibility of getting sufficient steam (shown by the diagonally hatched surface in Fig. 4); after the installation of an accumulator the operation was completed in 1½ hr. (horizontally hatched surface). Figures 5 to 7 show in diagram form the arrangement of a number of plants with an accumulator. At the Sandviken Ironworks, Sweden, there are three boilers: one furnishing steam to the hammers is fired with coal and with gas from the blast-furnace; the second for driving the Bessemer blower and the third for a train of rolling mills, the two last fired entirely with coal. The load being very variable, the consumption of fuel was very high. Sometimes the gas was lacking and it was necessary to depend entirely upon coal; when the gas was again available, the coal charged had first to be burned out. Before using the accumulator, four water-tube boilers were run at a pressure of 110 lb. Now, as the hammers require only 55 lb. of steam, the difference of pressure is utilized as follows: a special non-return valve X, Fig. 5, is placed in the line L_1 which connects the boiler steam pipe with the line L_2 going

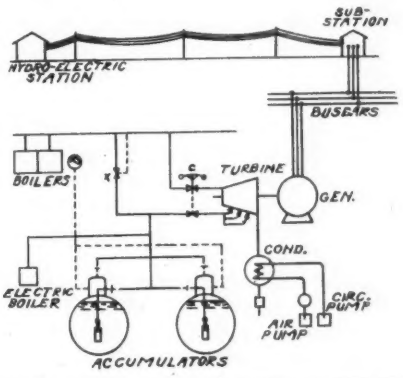


FIG. 7. DIAGRAM OF THE INSTALLATION AT THE ELECTRICAL POWER PLANT OF MALMOE, SWEDEN

to the hammers. This valve first directs the excess steam into the accumulator whenever the boiler pressure exceeds 55 lb. and secondly it acts to allow steam to go to the accumulator at any pressure, also as an ordinary check valve to shut off the boiler pressure when that is lower than the pressure in the accumulator. An ordinary valve, Y, and a steam reservoir are placed on the pipe, L_2, the reservoir acting as a shock absorber.

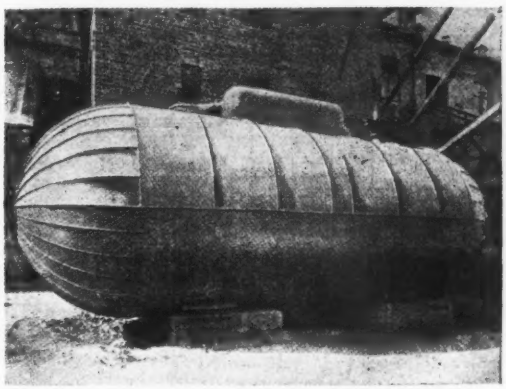


FIG. 8. ACCUMULATOR AT THE POWDERED BONE FACTORY AT STOCKHOLM, SWEDEN

The accumulator has a volume of 3880 cu. ft. and a capacity of 8800 lb. of steam. Figure 6 shows the arrangement at an iron works in which electric power is generated. After the purified gas from the blast furnaces has passed through a reheater, it passes on to the central plant, where it feeds the gas motors which drive the blowers and electric generators, the excess passing on to the boilers which furnish superheated steam at high pressure. Steam passes through a special valve, X, which controls the high-pressure stage of a two-stage turbine, and which, at a pressure of 1½ lb. under that at which the safety valves open, allows the steam to escape into the turbine. The quantity of steam is thus determined automatically by the quantity of gas available. A valve controlled by the governor C then allows the steam to pass either to the

accumulator or to the low-pressure stage of the turbine. The steam turbo-generator works in parallel with the gas-motor driven dynamos, so that the gas motors furnish the normal load and the turbine takes care of the peaks.

In the cellulose factory at Enso, Finland, four boilers running at 220 lb. are installed with their economizers, and fired with wood scrap. Energy is produced by a 3-stage 2000-kw. DeLaval turbine; the high-pressure stage works between 210 and 85 lb., the intermediate at 85 to 21 lb. and the low-pressure from 21 lb. to condenser pressure. The accumulator is here coupled to the intermediate stage of the turbine, and is designed for the same pressure. It has a volume of 9180 cu. ft., is 16.5 ft. in diameter and 49.5 ft. long and has a capacity of 39,600 lb. of steam. The regulating valves work together in such a way that a complete compensation for the varying loads is provided by the accumulator, so that the boilers have only to supply the average pressure required by the plant.

The electric power station at the town of Malmoe, Sweden, receives alternating current at 50,000 volts from a distant hydraulic plant. A great installation

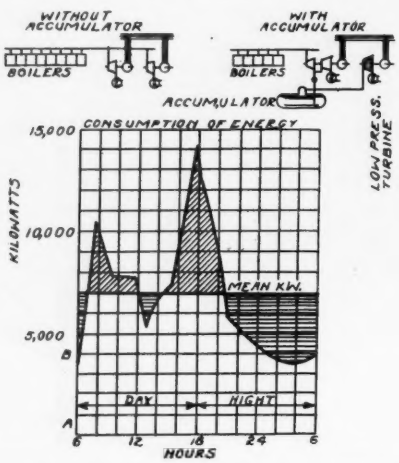


FIG. 9. DIAGRAM SHOWING THE COMPENSATION FOR PEAK LOADS IN AN ELECTRIC PLANT TRANSFORMED BY THE ADDITION OF AN ACCUMULATOR

of storage batteries, together with steam engines and boilers, kept continually under pressure, serve as a reserve in case of failure of the supply current. To avoid a costly addition to the storage battery, two Ruths accumulators have been installed and connected up with two boilers, each having a heating surface of 5400 sq. ft. They are placed out of doors, have a total volume of 16,000 cu. ft., work under a pressure of from 100 to 140 lb. per sq. in. and furnish between these limits of pressure about 79,200 lb. of steam. To compensate losses by cooling, a small boiler heated electrically charges them during the night; the pressure is found to diminish by about 7 lb. per sq. in. during the 24 hr.

SECRETARY HOOVER is working to make the Department of Commerce a real aid to business in reducing expenses and risks of doing business and in giving real information regarding conditions here and abroad which will serve as a basis for intelligent plans to increase manufacture and exports.

Novel Exhibit at California Industries Exposition

THE accompanying photo shows the display at the California Industrial Exposition recently held in the Municipal Auditorium at San Francisco.

The Pacific Gas and Electric Co., in conjunction with the Pacific Coast Steel Co., staged a novel display, the steel company furnishing one of its 54-ft., 220,000-v. snow type steel towers such as are used on the new Pit River line. This tower was fitted with insulators such as will be used on the new line, and on the top was a large sign designating its intended use.

In the base of the tower was built a small booth representing an electrical kitchen. Around the outside were placed a number of small trees, the idea being to indicate that the tower was standing in a forest. On either side of the entrance the Pacific Coast Steel Co. displayed samples of its products, and in the interior

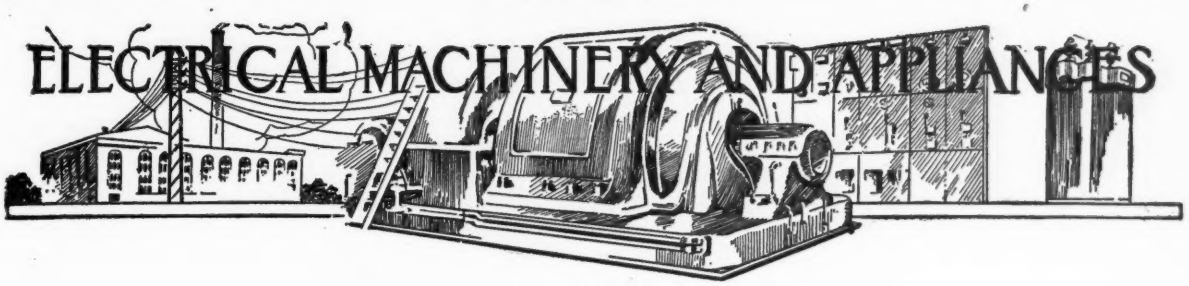
SHOWING 54-FT., 220,000-V. SNOW TOWER ERECTED IN THE AUDITORIUM

of the kitchen were shown the latest types of electric cooking apparatus.

In order to attract particular attention to the tower, a spark gap was placed between two of the insulators, and large spark coil was used to cause the current to jump across the gap, which made considerable noise and always attracted attention to the tower.

The display on the whole was considered a complete success, and was probably visited by at least 20,000 people.

THE UNIVERSAL gas mask has been fully developed for protecting the wearer against all poisonous gases not exceeding 2 or 3 per cent concentration in air where a safety lamp will burn, the flame showing that enough oxygen is present to support life. Universal gas masks weigh 8⅓ lb. and give a maximum time of protection. A fireman's gas mask has also been developed which has a smaller canister, weighs only 5½ lb., is less cumbersome than the universal mask, but has a shorter life. Tests of the universal mask are being made in actual use, after which complete specifications will be given. At the request of the Navy Department, the Navy gas masks have been tested by the Bureau of Mines for protection afforded in fire fighting.



Electric Elevator Drive---II

CONSIDERATIONS OF VALUE TO THE MAN SELECTING EQUIPMENT FOR A PARTICULAR KIND OF SERVICE. BY GORDON FOX

THE induction motor is not inherently adapted for elevator service as well as the direct current motor; it is widely used, however, with very good success. Low speed induction motors have not been developed for direct connection to traction type machines, and their use is therefore restricted to the worm and wheel type of winding machine. The type of motor used depends primarily upon the speed and the character of the service.

For low speeds, up to 150 ft. per min., but more particularly for speeds of 100 ft. per min. and lower, specially designed squirrel cage motors are well suited.

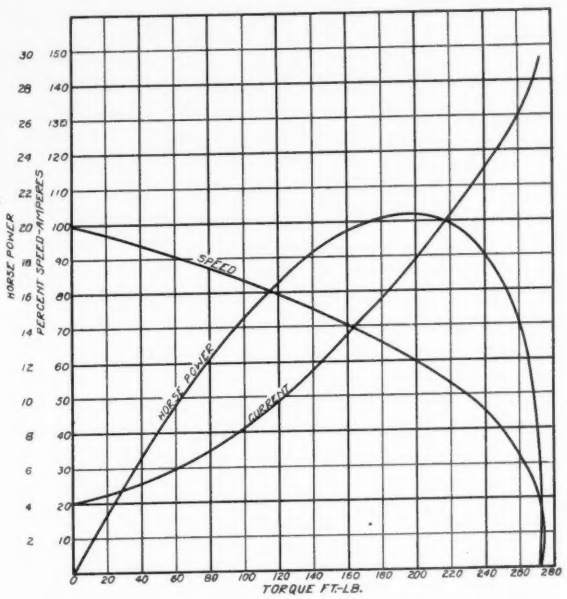


FIG. 6. CHARACTERISTICS OF SQUIRREL CAGE MOTOR WITH HIGH RESISTANCE ROTOR FOR ELEVATOR SERVICE

These are started by connecting the primary across full line voltage and stopped by disconnecting the motor and applying the mechanical brake. The control is usually of the drum type and is very simple. The motor has a small diameter, high resistance rotor and is so designed as to develop maximum torque, or thereabouts, at starting. The characteristic curves of a motor of this type are shown in Fig. 6. As the secondary losses occur within the motor, continuous service would tend to overheat it; but the class of service for which such motors are suited is usually highly intermittent. The squirrel cage motor has a number of advantages over the wound rotor motor for this class of service. The starting torque is the same for all positions of the rotor, whereas the starting torque of a wound rotor motor varies with

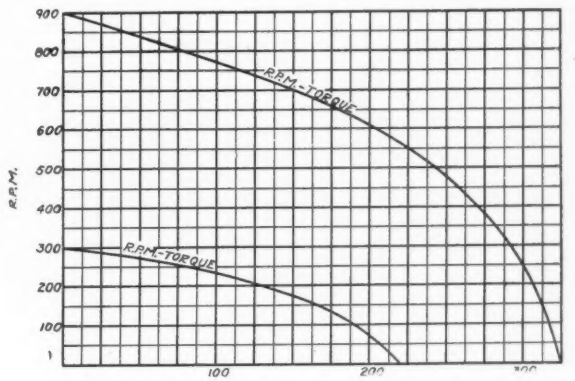


FIG. 7. SPEED TORQUE CURVES OF TWO-SPEED SQUIRREL CAGE INDUCTION MOTOR FOR ELEVATOR SERVICE

the rotor position. A squirrel cage motor will thus deliver about 25 per cent more torque at standstill than a wound rotor motor of similar size and design. For this reason the squirrel cage motor may be smaller and cheaper. The lighter rotor has less inertia, so that smaller brakes may be employed. The simplicity of both motor and control reduces the maintenance.

For service involving rope speeds from 100 to 200 or 250 ft. per min., simple wound rotor motors have been most commonly employed. The motor is started with sufficient secondary resistance to restrict the starting torque to less than maximum value and to restrict the starting current in corresponding degree. When capacity loads are handled it may be necessary to reduce the resistance to afford maximum torque before a start is obtained. The motor is accelerated by cutting out rotor resistance. It is not possible to obtain an effective slowdown and dynamic braking comparable to that of the direct current motor. Introduction of secondary resistance will slow down the motor if it is carrying a positive load, but if the load is overhauling, increasing the secondary resistance will cause the motor speed to increase. It is therefore necessary to depend largely upon the mechanical brakes for stopping. It is consequently difficult to secure a smooth, definite stop and brake maintenance is high.

The wound rotor motor has advantages over the squirrel cage motor for this class of service. Smoother acceleration is obtained, susceptible to some adjustment by control of the secondary resistance. Speed control is afforded in a limited measure. A squirrel cage motor thrown directly across the line would cause jerky acceleration, particularly with a light load. The higher speeds involve larger motors which are objectionable if thrown directly across the line. The speed regulation of a wound rotor motor with resistance short-circuited is quite good, affording fairly uniform running speeds with varying loads. The speed regulation of a squirrel cage motor with high resistance rotor is rather poor, so that running speeds vary considerably with load changes. This class of service may be fairly continuous, so that a larger squirrel cage motor may be required in order to dissipate the secondary losses. For these reasons, the field of usefulness of the simple squirrel cage motor has been more or less restricted to the lower speed equipments.

For rope speeds higher than 200 to 250 ft. per min. the simple wound rotor motor is not satisfactory, as landings cannot be made with sufficient accuracy without a slow approach. For this class of service, involving car speeds from 200 to 400 ft. per min., special two-speed wound rotor induction motors have been developed. This motor has two primary windings and two

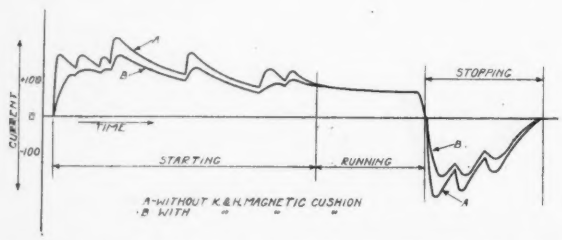


FIG. 8. CHART SHOWING STARTING CURRENT OF TRACTION TYPE ELEVATOR MOTOR. A, WITHOUT SERIES REACTANCE COIL. B, WITH SERIES REACTANCE COIL

secondary windings. These are grouped for two speeds having a ratio of about 3 or 4 to 1. The rotor has three collector rings and the rotor windings are so grouped that only that winding is effective which corresponds to the stator winding in use. The motor is started on the low speed connection and the secondary resistance is cut out until normal low speed is reached. The primary is then cut over to the high speed winding and the rotor resistance, again introduced, is again cut out to accelerate to full speed. The car is slowed down by cutting over from the high speed primary to the low speed primary winding, at the same time introducing the rotor resistance. The motor acts as an induction generator and regenerates as the secondary resistance is decreased, bringing the car to slow speed. The car is then stopped by disconnecting the motor and applying the brakes.

Another type of two-speed induction motor has two primary windings, usually designed for 3 to 1 speed ratio. The secondary is of the squirrel cage type, having high resistance end rings. Primary resistance control is used. The motor is started on the low speed connection with primary resistance in circuit. This resistance is cut out in steps. The primary is then changed over to full speed and the resistance again introduced. The resistance is again cut out to bring the motor to full speed. Deceleration is obtained by reverse procedure. This arrangement has advantages in its extreme simplicity. It combines most of the desirable features of the squirrel cage motor with accurate speed control resulting from the two-speed winding. The characteristic curves of a two-speed induction motor with high resistance squirrel cage rotor, are shown in Fig. 7.

Two-speed motors introduce some disadvantages due to the complexity of the double windings and consequent difficulty of repair. These windings also require considerable space and may necessitate a rather wide diameter rotor with considerable inertia. To overcome these stated disadvantages, a double motor set has been developed. This comprises a double frame, each with its own primary winding. Two rotors are mounted on a common shaft. One rotor has a squirrel cage winding, the other is equipped with slip rings. The motor may be started on the low speed squirrel cage unit and then brought to full speed by the wound rotor unit. If very heavy starting torque is desired, both motors may be utilized in starting.

Brakes

All elevator winding machines are equipped with brakes which may be either spring or gravity set and electrically released. Shoe brakes are preferable as they exert the same torque in both directions. Direct current brakes are solenoid released. A shunt wound magnet is necessary, since the variable amount and direction of armature current precludes the use of a series wound brake. The brake coil is soaked until the brake releases, when a protecting resistance is cut in series with the coil, preventing overheating. Compound wound brakes are also commonly used, the series coil being cut out with the series field, while the shunt coil is left directly on the line to do the holding. Alternating current brakes may be either solenoid or motor operated. The brake used should be capable of exerting a holding torque equal to full load torque of the motor. Elevators which are occasionally used to lift safes or other abnormal loads, are generally equipped with two brakes. A motor brake should not grip too suddenly. Dashpots are sometimes used to cause the brake to take hold smoothly.

Types of Control

Practically all elevators are operated from the car. Some form of remote control is therefore necessary. Some of the small, simple equipments are provided with a drum controller which is actuated from the car by ropes. The great majority of elevators are provided with magnetic control operated by a master switch in the car.

The magnetic controller for a direct current elevator motor will, in general, include the following items, in whole or in part:

Reversing contactors, mechanically interlocked; line contactor; accelerating contactors; armature shunting and dynamic braking contactors; field rheostat; field weakening relay; overload relays; main switch—pilot circuit switch and tryout switch.

All the contactors are provided with carbon to carbon or carbon to copper contact fingers in order to eliminate possible freezing of contacts, particularly when inching at floors.

Acceleration may be governed by current limit, counter-voltage or time element methods. The acceleration problem is complicated in that the motor should start smoothly and at the same rate either with a motor or generator load. Time element acceleration is receiving favor as capable of causing most uniform acceleration under varying conditions. The field rheostat is supplied with adjustable speed motors to control the field weakening. A field weakening relay is used to cause the field to be weakened gradually to prevent jerky action. This may not be necessary if the motor fields are inherently sluggish.

It may be of interest to note that smooth acceleration of high-speed traction type elevators is facilitated by some builders, through the use of reactance in series with the armature and starting resistance. This resistance tends to damp out the current peaks in starting and gives rise to more uniform torques. The effect of reactance is shown in Fig. 8, which shows the current peaks obtained in starting a motor with and without reactance.

The control for squirrel cage induction motors for elevator service commonly takes the form of a drum for reversing the primary leads. The control for wound rotor motors and multi-speed motors may be manual, semi or full magnetic. Alternating current contactors are used. The panel contains primary line and reversing contactors and secondary accelerating contactors, together with a main knife switch, tryout switch overload relays and reversed phase relay. Acceleration may be governed by primary or secondary current limit relays or by a time element relay. The current limit relay is of advantage in limiting the current input and prevents reducing the secondary resistance below maximum torque value before the motor gets under way. The time element relay gives most uniform results under varying load conditions and may be set for minimum current input with light loads with assurance that heavier loads will start as the contactors pick up.

Protective Devices Used with Elevator Control

The protective devices used with elevator control should receive brief mention. Hatchway or geared limit switches are employed to slown down and stop the car at the terminal landings. An additional overtravel limit may be supplied. An overspeed governor is mounted on the car and overload relays on the panel prevent damaging motor torque. An emergency switch in the car breaks both sides of the pilot circuit. Slack cable switches operate if a car sticks or the cables become slack for any reason. Reverse phase relays prevent reversal of travel direction. The control is arranged to prevent excessive plugging current and torques. Additional mechanical devices are guide grips and pneumatic or spring bumpers.

Power Ratings

The horsepower rating of an elevator motor is based on the net load corrected for friction losses by use of an efficiency multiplier. The total efficiency of elevator drives ranges from 25 to 85 per cent. Efficiency figures from 25 to 60 per cent may well be used for worm wheel equipments, depending upon the consideration outlined above. Traction type machines are more efficient, 80 per cent being a representative figure for a direct connected unit with 1 to 1 roping.

Elevators are more or less intermittent in operation. Where service is very irregular, the horsepower required may correspond to the 15-min. rating of the motor, whereas, with fairly regular service, the 60-min. rating should be taken.

One of the limiting conditions in elevator service is starting torque. Due largely to forcing out of lubricants, the starting torque of a worm drive type of machine may be easily twice the normal running torque. Except in the case of high speed elevators the inertia of parts is not a determining factor, but it adds somewhat to the starting load. A variation of 10 per cent in line voltage may reduce the developed motor torque 20 per cent. The motor selected should be capable of developing a starting torque not less than 250 per cent of the hoisting torque required at maximum load. For low speed elevators, starting torque may determine the

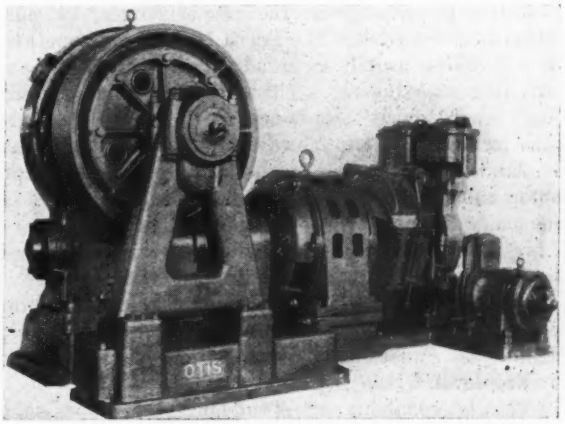


FIG. 9. TRACTION TYPE MACHINE DRIVEN BY TWO-SPEED SQUIRREL CAGE INDUCTION MOTOR WITH MICRO DRIVE

motor size as intermittent operation may prevent much heating.

As a brief example of motor selection, we may consider an elevator having a capacity of 3000 lb. and a hoisting speed of 250 ft. per min. The counterweight will cancel the car weight and 40 per cent of the capacity leaving a net lift of 1800 lb. The power required is:

$$HP = \frac{W \times V}{33{,}000 \times e} = \frac{1800 \times 250}{33{,}000 \times 50} = 27.3$$

The efficiency is taken as 50 per cent. The drum diameter is 30 in. With a worm and wheel reduction of 28 to 1, the full load motor speed required is:

$$RPM = \frac{V}{3.1416 \times d \times r} = 900$$

The full load motor torque =

$$\frac{HP \times 33{,}000}{2 \times 3.1416 \text{ r.p.m.}} = 19 \text{ lb.-ft.}$$

The motor selected must be capable of developing

50 lb.-ft. torque at starting. A motor might be selected having a full field speed of 450 r.p.m. and a 2 to 1 field ratio, giving 900 r.p.m. for full speed running condition.

Micro Levelling

A discussion of elevators would not be complete without mention of the so-called micro levelling drive. This is shown in Fig. 9. The micro levelling elevator machine consists of two essential parts, the main hoisting machine and the micro machine. The main machine, with the exception of the brake, may be of any type and involves no special features. The brake is usually of the regular shoe type except that the housing is not bolted to the bedplate but is fastened to a worm gear so as to revolve with it. The worm gear is driven, through a worm, by a small auxiliary motor, termed the micro motor. When the micro is at rest, the main brake acts as a brake. When the micro motor operates, the main brake acts as a clutch to drive the main machine from the micro motor. The micro motor, in turn, is equipped with a brake.

With the micro levelling elevator machine there are two controllers, one to control the operation of the main motor, the other to control the micro motor. The main controller is operated in the usual manner, by push button or car switch. The micro controller is operated by a levelling switch mounted on the car frame and travelling with the car. The micro controller contains "up" and "down" contacts, which are actuated by cams located in the hatchway. As the car approaches the landing at which it is desired to stop, the main motor and control functions in the usual manner. If the main machine brings the platform either below or above the landing, the micro will then raise or lower it until it is level with the landing, at which point the micro control is cut out. If the car rises or settles due to subtraction or addition of weight, the micro equipment again functions to return the car to the exact landing level.

The micro drive offers advantages in passenger service in aiding accurate floor stops, saving time and avoiding inching. For freight service, it is particularly effective in maintaining exact levels to facilitate movement of trucks.

Another development of interest is the use of multi-voltage control of direct current motors. Where a number of elevators are operated in one building, the resistance losses are such that equipments to furnish multiple voltages may be justified through the savings possible. Acceleration, deceleration and speed control are then obtained by transferring the motor armature from one voltage to another.

Identifying Conductors in Cables

An Ingenious Method of Identifying Conductors Without the Assistance of a Helper. By J. M. Row

IT SOMETIMES happens that one is called to perform a task alone, when the very nature of the work makes it seem almost necessary to have a helper.

Such was the case one morning when the writer went out on a cable testing job and found no help. I had a cable containing 20 conductors, about a mile long, which were to be identified at each end and marked. This is the way the job was done, with only one trip to the distant end and return.

First a tag was hung on one wire and marked No. 1. Then two wires were connected together and tagged Nos. 2 and 3. Likewise three wires were connected together and called Nos. 4, 5 and 6. Then a group of four Nos. 7, 8, 9 and 10. After which followed two groups of five each, one of which was grounded, so that they might be identified at the distant end.

Then at the distant station with my circuit detector, all these groups were identified and connected up as shown in the diagram. The conductor which formed a circuit with no other wire of course was No. 1, and I marked it as such, and connected it to one in the grounded group of five, which was marked No. 20, since it might be any number from 16 to 20, as may be seen by referring back to the home station. One in the group of two was numbered 2, and connected to one in the grounded group which was marked No. 19. The other in the group of two must necessarily be No. 3 and it was connected to one in the underground group of five, which was labeled No. 15. One in the group of three was tagged No. 4, and connected to one in the grounded group which was marked No. 18. Another in this group of three was called No. 5, and connected to one in the ungrounded group of five, which was called No. 14. The remaining one in the three group of course was No. 6, and it was connected to one in the group of four, which was given the number 10. Another in group four was marked No. 7 and connected to one in the grounded group which was called No. 17. Another from group four was labeled No. 8, and connected to one in the ungrounded group of five, which was marked No. 13.

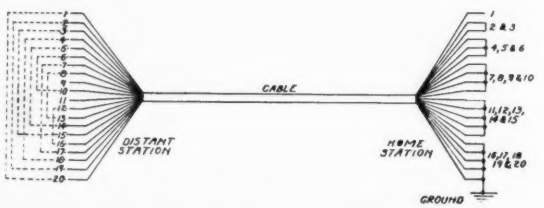


DIAGRAM SHOWING METHOD OF CONNECTING AND LABELING WIRES IN CABLE

The remaining one in the group of four is No. 9 and it is left dead-ended. This leaves one in the grounded group, which is No. 16, and it is connected to one remaining in the ungrounded group of five, which is marked No. 12.

Now with a sketch of the connections, as made at the distant station, we may go back to the home station, and identify and label every conductor just as it is labeled at the distant station.

For instance, suppose we disconnect one of the wires from the group of three, and test for a continuity of circuit between it and the other groups, and find we have a circuit to the group of five which is not grounded; by referring to our sketch we find that the one in group three which is connected into group five is No. 5, after marking it we proceed with another in the same manner, until they are all labeled. The ones which were left open-ended may be identified since they are in different groups.

Industrial Aspect of Superpower System*

NEED OF ECONOMY IN MANUFACTURING—ANTICIPATED FUEL SAVING IN STEAM-ELECTRIC POWER PLANTS—CLASSES OF PLANTS PROVIDED FOR. BY HENRY FLOOD, JR.

AT THE annual meeting of the American Society of Mechanical Engineers last December, Professor Breckenridge, chairman of the Advisory Board of the Superpower Survey, briefly summed up the essential elements of the superpower plan, as follows:

(a) The generation of power in steam-electric plants of large capacity and of the highest economy.

(b) The location of these steam-electric plants advantageously with relation to coal mines, condensing water, load centers and coal distribution.

(c) The extensive development of the hydroelectric resources of the area.

(d) Construction of trunk transmission lines for the interconnection of the generating stations, both steam and water, with the principal load centers of the zone.

(e) The making available of a cheap, reliable and adequate power supply to the heavy traction railways by means of the interconnected system of power plants by trunk transmission lines.

(f) A unified system of control in charge of a power dispatcher.

(g) The delivery of the primary power to the electric utilities within the zone.

(h) The local distribution of all energy by the electric utilities.

While the region selected was taken because of its intense industrial development, this same principle can be applied to any other section of the country, and to the entire country with results similar to those that will accrue to the selected district along the Atlantic seaboard.

The financial depression through which we have just passed has removed the immediate necessity of intensive power developments, but all signs point toward renewed industrial activity, and when such begins, the lack of an adequate power supply will immediately be felt.

There is a reason why power, and particularly cheap power, will become of more and more importance to this country than has been the case in the past. Prior to the World's War, this country was a debtor nation, importing large amounts of manufactured articles for which we partially paid by the exportation of raw materials to Europe. Our own natural resources had been largely developed through the borrowing of foreign capital, so when the World's War broke out, we had a large trade balance standing against us. The World's War, however, has just reversed our financial status. During the early periods of the war, we exported large amounts of munitions and war supplies to the various belligerents abroad and even before we entered the war, we had liquidated the adverse balance and had become a creditor nation. By our own entry into the war we increased Europe's obligations to us so that upon its termination and that of the period immediately succeeding, Europe had become a debtor to this country to the extent of over fifteen billions of dollars.

The question as to how Europe will liquidate this debt is one of great concern to our ablest financiers. It is self-evident that the debt cannot be liquidated by gold, as today we own a very large proportion of all of the free gold available. It is probable that the larger part of this debt must be paid through goods and our manufacturers, therefore, must be in a position to meet competition with these goods.

While England is paying her labor more pounds, France is paying her labor more francs and Germany is paying her labor more marks than they did prior to the World's War, the currencies in all of these countries are so much more inflated than they were prior to our entry into the World's War that their labor when compared to our own is even cheaper today than it was in 1914, and the problem of our manufacturers becomes that of being able to meet these relatively deflated foreign labor costs.

Again, our own needs can be supplied by 9 to 10 mo. employment of the production facilities we have now available in this country, and in order to keep those facilities at work it is necessary for us to develop foreign markets for export which will throw us into competition with the cheap labor of Europe in those markets as well as in our own.

Power in connection with the competition of cheap labor, becomes of paramount importance. There is a definite and important relation between the amount of machine power used per wage-earner and the value of the product he produces. Thus, while in 1899 we were using about 2 hp. per wage-earner with a resulting annual value of product of $2400, by 1914 we had increased our machine power to 3.2 hp. per wage-earner with corresponding increases in the value of his output to $3400 a year. As yet, there is no European country approaching this productivity per wage-earner; but Europe learned much from us during the World's War, and our safe way to guard industry is by increasing the machine power available to each wage earner, thus supplementing our man power to such an extent that we can over-balance the low labor costs against which we must compete.

NEED OF INTERCONNECTION

THE ELECTRIC utility systems of this country have been the foremost advocates of efficiency and since their inception their history has been one of price reduction without a break until about 1918. The continual lowering of rates during that period by the electric utilities was made possible principally through the increased efficiency of operation, and even the increases in the rates granted during the past few years of high prices have not been at all in proportion to the increases in the prices of the commodities that go to make up their product.

The electric utilities are, however, beginning to reach the point of minimum cost for independent development. The possibilities of large reductions in cost for this operation of existing power plants are not great. The independent development of water powers of the nature available to our Atlantic seaboard is restricted to developments of comparably small size and the interconnection between municipalities and even between companies under present arrangements yields little as an economic

*Abstract of paper read before the Washington, D. C., Sections of the A. S. M. E. and A. I. E. E.

result except in insured reliability to service. In other words, we have come to a turning point where to do as they have been doing, the electric utilities must progress slowly and laboriously, but where, by changing their systems now serving individual municipalities or small sections to one serving immensely large areas through co-ordinated effort, means large returns to the public and to themselves.

The Superpower Report can, in fact, be summed up as a prophetic study of what will happen if the utilities and the public co-operate for the co-ordination of the physical structures for all future construction. It is merely a more efficient expansion of past practice. The electric utility started out with the power plant serving one business block. It grew until it served a municipality and then it spread out to the suburbs, until finally, today, we find interconnected systems serving areas of many thousands of square miles.

The Superpower Report discusses the principles through which financial benefits, in respect to the future development of our power system, will accrue not only to the electric utility companies, but to the people as a whole. The time available for the study was limited and while unusual co-operation was extended by electric utilities, railroads and manufacturing companies, it was still impossible to treat of the subject except in general. Each local condition could not be specifically considered and before the actual construction required for the superpower system can be started, it will be necessary to enlarge upon the work done by the engineering staff of the survey by making such a detailed study that each of the local conditions can be met. This may result in certain modifications of the location for power plants, transmission lines and load centers, but it will in no way affect the principles established by the Superpower Report.

Present Available Development

Fortunately, the nucleus of a superpower system is with us. We do not have to tear down the entire fabric erected at much expense and many years of labor; in fact, the nucleus in power stations alone amounts to 52 per cent of the capacity that would be required for a superpower system were it in operation by 1925.

The existing capacity in steam-electric plants within the superpower zone in 1919 was 4,000,000 kw., while that of hydroelectric plants was 452,000 kw., making a total of 4,452,000 kw. available for service of this zone. Of this amount the engineers of the Superpower Survey determined that 3,255,000 kw. could be economically retained and incorporated into the system, and as a result nearly 80 per cent of the existing power plant capacity would continue to function and have continual useful life.

Under the conditions of electric utility operation for 1919, the average capacity for steam-electric plants was approximately 10,000 kw. By the elimination of the smaller and less efficient of these plants, the average capacity of the plants retained was increased to 44,600 kw., and while all of the steam plants under the operating conditions of 1919 required about 2.73 lb. of coal per kw.-hr., the steam-electric plants retained for incorporation into the superpower system under the same conditions would require but 2.1 lb. of coal per kw.-hr., which is a saving in fuel of 23 per cent.

The estimated reproduction cost of all power plants serving the superpower zone in 1919 was approximately $598,000,000, while the same value for these plants retained amounted to $418,000,000, or about 70 per cent of the investment then made in power plants. Because of their larger size, and the great individual capacity of the generating units, the investment per kilowatt of capacity for these retained plants is materially lower than that for all of the plants existing in 1919.

Bases for Expected Economies

The economies to be effected by the superpower system are based upon the best use of each element going to make it up, so that the result will be the lowest possible cost obtainable. Accordingly, the retained steam-electric plants are operated as peak load plants, operating at about 20 per cent annual capacity factor in 1925 and only about 17 per cent annual capacity factor in 1930.

The chief reliance of the superpower zone must be placed on coal-produced power, inasmuch as under the most favorable conditions of water power development, it is hardly possible that even by 1930, more than 21 per cent of the entire energy requirement could be produced by hydroelectric plants. The success of the plan, therefore, rests upon so constructing and so operating the system that the chief producers of power, that is, the base load steam-electric plants make each unit of energy at the lowest possible cost.

High capacity factor operation is the essential requirement for the cheap production of power in base load steam-electric plants and the entire structure of the superpower system has been built up to make it financially and physically possible to operate the base load steam-electric plants at high capacity factors. Base load steam-electric plants can, therefore, be designed to operate under loads having practically no daily variation in magnitude and but little variation in seasonal outputs, and under such conditions, exceptionally good performances can be expected from them.

The policy of the engineers of the Superpower Survey was to hold to practices which had met the test of time and accordingly, the specifications for the conditions under which the base load steam-electric plants would operate do not present anything new or questionable. The steam pressure recommended of 300 lb. per sq. in. with a final temperature of 652 deg., and an absolute pressure at the turbine exhaust nozzle of 1 in. mercury are conditions under which a number of steam-electric plants are operating today, both in this country and abroad, and the major troubles from such operating conditions have been determined and eliminated.

Owing to the variation in the cost for fuel throughout the zone and to the specific conditions under which each station would have to operate, three main classes of stations were provided; namely, those of very simple design with their boiler rooms equipped with stokers, but with no other heat-saving devices; those with boiler rooms equipped with stokers and economizers; and lastly, the very efficient type of station, utilizing stokers, economizers and air preheaters. Each of these groups was subdivided into a class for burning bituminous fuel and one for burning anthracite fuel.

The production of power in the anthracite fields, however, proves to be most attractive, provided certain contingent conditions can be met. There is not at pres-

ent a sufficient supply of the smaller sizes of anthracite coal to meet both the requirements of superpower plants located within the region and the natural market for such coal; but if a large number of anthracite mines were electrified, through which process they would receive large financial benefits, an adequate coal supply would be made available to superpower plants located in the anthracite region. Long term coal contracts between the mine owners and the owners of the superpower plants, at a price which is competitive with bituminous coal delivered at tidewater, is another condition that must be fulfilled to make the operation of such plants profitable.

From the results of conferences with anthracite mine operators, it is believed that such contracts are entirely feasible and that arrangements can be made between the anthracite mine operators and the power plant owners, which will result in their mutual benefit.

The construction of base load steam-electric plants in the anthracite region can be made particularly attractive, due to the diversity of demand existing between that region and that along the seaboard between New York and Philadelphia. By connecting the proposed base load steam-electric stations in the anthracite region with the principal load centers along the coast, it would be possible to operate such plants at a very high capacity factor, thus producing power for about 5.7 mills per kw.-hr. at their switchboards, even with the high prevailing costs for 1919, and this power can be transmitted to New York and Philadelphia with a resulting cost of about 7.3 mills per kw.-hr., which will show a saving of over 10 per cent of the cost to produce power in plants located in those load centers.

Hydroelectric Plants

The use of hydroelectric plants on the Delaware River in connection with the proposed base load steam-electric plants for the anthracite region will be a large factor in providing cheap power, both to the industrial regions along the coast and the anthracite mining regions.

The existing transmission systems owned by the electric utility companies are in most cases unsuitable for service as interconnecting transmission lines or trunk transmission lines, owing to their lack of adequate capacity to transmit the amounts of power which will be required upon the proposed system, but they nevertheless form an important nucleus of the ultimate superpower system in that they will become the distribution lines over which the power produced will be transmitted from the load centers to its ultimate point of utilization, and this existing network of transmission lines, instead of being scrapped and discarded, will, on the other hand, have to be largely extended in order to dispose of the energy produced by the super-power system.

The location of base load steam-electric plants with reference to coal delivery routes is of the utmost importance. Insurance to continuity of service from a reliable coal supply is obtained by locating base load steam-electric plants at points where coal may be received from the mines over more than one route. In addition, the location of the base load steam-electric stations with reference to the coal routes affects the total production cost in that by a judicious selection of the location, the delivery cost for coal may be reduced.

For the proposed superpower system as of 1925 and 1930, while the freight rates used were taken at a higher value than those actually paid in 1919, the unit cost of coal delivered to the superpower plants was lower than the actual cost of coal delivered to the steam-electric stations in operation during 1919, and this reduction in unit cost is entirely due to the location of the base load steam-electric stations at strategical points in respect to the cost of coal.

Steam-electric stations, while of prime importance in the superpower zone, due to the fact that at least 80 per cent of all the energy produced must be generated therein, cannot of themselves produce the results prophesied in the Superpower Report. Hydroelectric developments are of great importance because through their use the base load steam-electric plants can be made to function so as to produce cheap energy. Finally, without the interconnecting transmission system over which loads may be transferred, thus taking advantage of diversity capacity, diversity economy and joint reserve, the superpower plant as presented would be impossible.

Trouble Hunting---XIII

Revamping the Main Works. By John Pierce

BACK AGAIN at the main works, I started in to clean out and tear down in place of trying to build up. I found that in the long run it would be much cheaper than trying to go ahead using my predecessor's plan. For instance, I found a boiler which was being operated under steam set away off from the main battery of boilers that we were intending to work over and put in commission. This boiler was to supply steam to a point to put the oil, or chapopote, from the storage tank to the boiler. I am making a rough sketch showing how the lines were laid. The line leaving the boiler was a 4-in. line and ran to point A a trifle over 500 ft. away. There it was reduced and went all the way back to the pump as a 3-in. line. From point A it ran at a right angle for 200 ft., cross over for 6 ft., then doubled back on itself for 100 ft. Here it shot off at right angles again and ran 50 ft., then went south again for 100 ft., again crossed over 6 in., came back, crossing itself, for 500 ft. and right angled to the pump. The distance could have been spanned with the first run of 4-in. pipe.

In all this line there was not a single union except that at the pump; why it was built this way nobody knows. It was the strangest piece of work I'd ever seen and no one had any idea what the installer's ideas were. I rather figured it out that perhaps he had started it all right and then one of the superintendents came along and had him change it, and later the other came along and had him change it again. I'm willing to give him the benefit of the doubt, but I can't see why any man, steamfitter or otherwise, would run a line of pipe so far and use neither stop valves, unions, nor expansion

joints. I dug this line up and put in a line direct to the pump and used two expansion joints. I did not intend to have any lines buckling up and breaking on me nor to have any leaky joints. I found a great number of new expansion joints on the place, but in all the years these properties had been in use not one had ever been used. The boiler of which I have been writing was badly bagged and was fired with wood. Without saying anything, I watched carefully, for two entire days, managing my work so that I'd be within hearing distance of the "blowdown" and not once in those two days was the blowoff opened. I certainly read the riot act to that bunch of Mexicans and ordered the old girl to have a "purge" every 2 hr. day and night. I had to bring an old alarm clock to the boiler house so they could tell when to do it, as they had no watches. I had her cooled down and cleaned up, and then I rigged up a forge under the old sister and patted her with a 16-lb. sledge. We drove back the blisters and got her going once more. The men told me they had never been accustomed to "blowing down," as the previous masters had never said anything about it, and they did not know that it would be of any benefit. They were also in the habit of scraping the flues only once every two weeks when the boiler was washed. If any of the readers has ever burned mesquite wood, they can imagine about how much "hole" there would be in

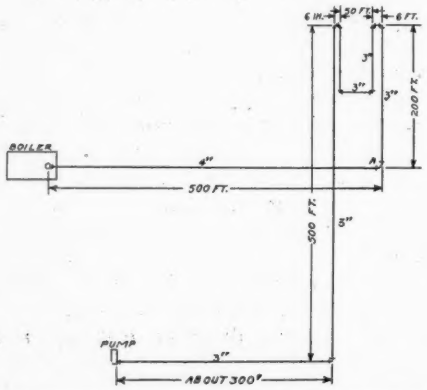


DIAGRAM SHOWING PIPING CONNECTIONS FROM BOILER TO PUMP

a 4-in. flue in two weeks' run, and will also know about how much nasty sticky gum would have accumulated in the flue. Blowing did no good. They simply had to be scraped. I carefully explained to them the great advantages they would derive in the way of less labor, and the company in better service, if the flues were scraped every day. I ordered them scraped each morning and the boiler to be washed once a week, in addition to the "blowdowns." They soon, like children, saw how they had been working harder in order to avoid a little work, and I think that from that time on they never missed scraping the flues each day and they seldom failed to blow down as they should.

While changing the line to the pump I had a crew of men working to get the conglomeration of materials straightened out so we could begin assembling the engines and compressors. There had been originally two air compressors. One was a belt-driven machine, belted to a Westinghouse high-speed engine, and the other was steam driven, the steam end being compounded and running, before being destroyed, very nicely. There were the remains of the Westinghouse engine to account for also and while nearly all the pieces were eventually found, some new ones had to be ordered and some of the simpler ones we made. Imagine, if you can, the thoughts that must be going on in a Mexican's think bonnet when he takes the deliberate trouble to take down a great lot of machinery, rig up skids, tripods, and other means to get it all in a great heap. This was what had been done to these two compressors, the Westinghouse engine belonging to them, the engine that was to have driven the generator, hoists, pumps—even to pulling the pumps 250 ft. out of the shafts—and two great heavy 500-hp. hoisting engines.

I got the duplex steam-driven compressor out of the heap where it had been piled and began assembling it. I found it was shy a few valves on the air end of the high-pressure side, and naturally the springs and covers were gone also. We had, in the warehouse, a few valves, enough to finish the job, and also springs. The caps I had to turn out in the shops. The low-pressure rod on the air end was bent in two neat reverse curves, and I hunted up a piece of rod from an old straight line compressor and turned out a new one. It so happened that the rings on both ends were in good shape, else we would never have gotten it ready without ordering new ones, since I had no ring metal of the low-pressure diameter.

The intercooler was badly cracked and looked almost hopeless. I found enough "Smooth-on" cement to fill the crack after I had expanded it somewhat with heat, but I did not trust to "Smooth-on" alone. I made a "soft" patch and bolted it on with gasket rubber between the patch and the intercooler. The crack ran lengthwise of the intercooler. Then over this, the shell being none too heavy, I bolted four rings that encircled the drum and we had that old lady tied down.

One compressor now being ready, I turned my attention to the boilers. These had been, at first, four "Cook" vertical boilers of 250 hp. each. They had carried, for years, 150 lb. pressure. My predecessor had cleaned them out and got them ready to fire up. He fired one of them up one day and it blew out a man-hole gasket. He then decided to try out the others. Instead of rigging up a cold water test, he pied another one up. At 40 lb. the safety valve began to show signs of life. He was waiting to raise steam to 125 lb. so he went up and screwed down the safety. The gage apparently went up only about a pound when he had to set it down again. This kept on recurring; still his gage showed only 45 lb., although the safety was set as tight as he could set it with a 24-in. wrench. He had come down off the boiler and merely stepped through the door when she went up. The reports vary as to how high she went, but most of the Mexicans said at least a mile high. At any rate, she came down over 1500 ft. away and about 500 ft. higher up on the side of the mountain. At that time they could not account for it, but it was later found that while the steam had kept her going after she started she was started with a box of dynamite. Of course each of the superintendents said the other must have done it. Well, four Mexicans went to heaven on the "Casey Jones" road. There was hardly a bit of them found after the wreck.

The boilers then were ordered inspected. The inspector found the steam gage and found it still registering 45 lb., though what it should have registered will always be a mystery. The safety valve was never found. The inspector condemned the three remaining boilers and a call was sent to the other companies pertaining to the same mother company and six boilers were sent to this point. No two of them were alike either as to type, size, or shape. There was but one thing to do, though, and that was the best one could do.

There had been a fellow brought in as inspector who was an old friend of the old superintendent, and naturally in inspecting this new set of old boilers he put them on the skids, saying they would stand only 60 lb. pressure. I asked him how he arrived at these figures and he told me. I cannot remember all he said, but one of the things was that the steel had originally been tested and found to have a tensile strength of 40,000 lb. Age had cut this down to 50 per cent, and so on. I asked him where he had learned to be a boiler inspector and he said he learned it while working as a boilermaker. Upon asking him the extent of his boiler-making experience, he said he had been a rivet heater 15 yr. ago while the regular boilermaker was putting a patch on a boiler. I began to take calculations and, according to my figures, with a factor of safety four to one, found them good for 110 lb. I'd rather have had a five to one factor, but we simply had to have steam. I did put a cold water test on them that was frightful. I tested every one at 320 lb. cold water, and maintained this pressure on each of them for an hour. The Mexicans begged me then to go ahead and get them ready for steam, simply because they had to have work, and until we got steam and got a part of the plant to moving there was only a limited number of them could be used. We lined the fronts of the boilers up and began to brick in around them. The brick we secured by taking down the wall that had in the past supported the other boilers scattered about the place but now gone to ruin.

Ice Making by the Center-Freeze System

FIVE-TON BLOCKS ARE PRODUCED IN THIRTY HOURS FROM RAW WATER. BY A. G. SOLOMON

WHEN MANUFACTURED ice is under discussion, the engineer's mind will generally form a picture of cakes of clear ice weighing either 300 or 400 lb., and the cans in which the ice is frozen will also have a place in the picture.

Plate ice is seldom given a thought, for there are but few plants where plate ice is made.

Not one out of a thousand refrigerating engineers would form a mind picture of ice that is frozen in 5-T. sheets and the freezing done outward from the center.

There is one plant of which the writer has knowledge where the ice is manufactured on what is called the center-freeze system. Cakes of ice weighing 5 T. each are frozen around a number of 1-in. pipe, and after being thawed loose these cakes are sawed into 300-lb. cakes ready for the ice vault and the trade.

TANK AND GRIDS

THE ICE tank proper consists of four separate compartments 19 ft. 6 in. by 10 ft. 8 in. by 13 ft. deep. These four compartments are really one tank divided into the four compartments of the foregoing dimensions. The tank is made of concrete, the walls and partitions being extra thick, as the ice hangs free in the tank from the headers resting on the walls.

The ice is frozen on what are called grids. Each grid consists of a header and 40 drop pipes. The headers are made up of a 2-in. pipe inside of a 5-in. Both 2-in. and 5-in. are extra heavy.

The 5-in. header is drilled on 5½-in. centers for forty 1-in. pipes, and a 1-in. coupling is welded at each drilled hole. The couplings that are welded on give a better holding power than would be secured by screwing the 1-in. pipe direct into the header.

The 2-in. inner pipe is drilled and tapped for forty ¼-in. pipes.

When the complete grid is assembled, the 2-in. pipe is inside of the 5-in., with the holes for the drop pipes coming in line. The 2-in. pipe extends through the flange at one end of the 5-in. header, the flange being drilled and tapped for the purpose. The other end of the 2-in. pipe is welded closed.

Into each of the forty ¼-in. openings of the 2-in. inner pipe is screwed a piece of ¼-in. pipe 13 ft. long. The ¼-in. pipes are open at the bottom end. Into the couplings that are welded on the 5-in. header are screwed 40 pieces of 1-in. galvanized pipe 13 ft. 4 in. long. These 1-in. drop pipes are welded closed at the bottom end.

When in operation, the brine enters at the open end of the 2-in. inner header and flows down through the ¼-in. pipes, then back up through the 1-in. pipes and into the 5-in. header. The outlet for the brine is at the opposite end of the 5-in. header from where the brine enters the 2-in. pipe. The outlet is also 2-in.

The flanges used on the 5-in. pipe are specially-made square flanges and rest in a guide-like arrangement on the walls of the tank. This insures the grid being in its exact place so that the inlet and outlet brine connections can be easily made.

One of the 1-in. drop pipes at each end of the header and one near the center are made about 4 in. longer than the others and the lower ends fit between blocks in the bottom of the tank. This holds the grid in a true vertical position, and prevents any swaying that could otherwise be caused by the agitation of the water.

The header that carries the cold brine from the brine cooler to the grids is provided with a valve at each grid. Between the valve and the 2-in. inlet opening of the grid is a piece of hose instead of pipe. The use of the hose makes a somewhat flexible joint and this makes connecting easy and quick. Special unions are used at both inlet and outlet ends and the tightening is done by means of a yoke and long threaded screw having a handle for turning. No wrenches are needed for disconnecting or connecting.

The outlet brine leaves the 5-in. header and flows

by gravity through an insulated trough to the receiving tank. A centrifugal pump takes the brine from the receiving tank and discharges it through a shell and tube brine cooler and into the inlet header to the grids. A brine pressure of about 20 lb. is maintained.

A valve, hose and special union are also provided at the outlet end of the 5-in. header. The flow of the brine through the grids is regulated at the outlet valve, the inlet valve being wide open.

There are seven grids in each of the four compartments.

Any water that is fit for use as drinking water can be used for the making of center-freeze ice, and if the system is properly operated the ice will be perfectly clear and pure. This ice will not contain any sediment or air needles so common in both distilled water ice and the raw water ice that is made in cans and frozen from the sides.

No filtering is necessary, nor is the water treated in any way, no matter how much hardness it contains.

While freezing, the water is agitated by means of air at a pressure of about 20 lb. In the bottom of the tank, between the grids, are the perforated air lines. These air lines are ¾-in. galvanized pipe, the perforations are 1/16 in. and are spaced 18 in. apart. The air supply header extends along the top of the tanks and at each compartment is provided with a valve. The connections are made with ground joint unions so that the lines can be easily removed for cleaning. The small holes must be reamed out frequently, as they become blocked with fine particles of sand. This blocking of the air lines is rather troublesome when the brine temperature is carried below zero. Each compartment is provided with a 4-in. drain valve.

Cycle of Operation

We shall begin with a compartment that is empty and ready for filling and follow the water until it is delivered to the ice vault in cakes of clear ice.

The raw water is pumped into the tank until the proper level is reached. While the filling is being done, the brine is turned on two or three of the grids so that the temperature of the water is reduced as the tank fills. Air is also turned on while the tank is filling. This insures continuous agitation for all the grids.

As the temperature is lowered, a thin coating of ice will form on the pipes of the grid through which the brine is circulating. Just as soon as it is noticed that ice is beginning to form the brine is turned through all of the grids. This will cause uniform freezing on all the grids and all the ice will be the same thickness when the pulling is done.

During the first few hours the ice forms rapidly as the insulating effect is slight. The diameter of the ice around the drop pipes gradually increases until the ice touches the ice on the other drop pipes. From this time on the ice surface will tend to become more and more level. When the ice has reached a thickness of about 10½ in., the rounded appearance is entirely gone and the surfaces are perfectly smooth.

The thickness of the ice is measured by means of a pair of large calipers that have a graduated arm and pointer at the top end. When the calipers show the ice to be about 10½ in. thick, the brine is shut off all seven grids of the tank and the ice is then allowed to temper for 2 hr. before pulling. This will prevent cracking. The air agitation is allowed to continue till all the ice is pulled. After the brine has been shut off, the thickness of the ice will increase about ½ in. during the tempering time. This will make 11-in. ice.

At all times during the freezing the air agitation must be closely watched. The lower the temperature of the brine, the closer must be the watching, for the moisture that is contained in the air will freeze and stop the small perforations. Interruption of the agitation will mean bad looking ice.

There is no point of temperature too low for the center freeze system as there is with the can system. The colder the brine the better, as the ice can be made so much quicker. With an absorption system of refrigeration the temperature of the center freeze brine is often several degrees below zero. It is not uncommon to freeze 11-in. ice in 30 hr. and have the ice come out perfect in clearness and without the slightest cracking.

After the formed ice has been allowed to temper in the tank for 2 hr. the unions at the inlet and outlet brine connections are disconnected and the pulling begins. By means of an electric hoist and crane, one grid is hoisted and delivered to the table for sawing.

The framework of the table is made of "I" beams and channel iron and fastened with rivets and heavy through braces. This frame is mounted on a shaft which allows the table to be placed in a vertical position to receive the ice from the crane and then to assume the horizontal position while the saw is being operated. This moving of the table is accomplished by means of a reversible motor which is belt connected to a shaft. The power is then transmitted to the table shaft by means of gears.

The floor of the table is made of hard wood and is divided into sections 22 in. by 44 in.; the saw travels between the sections.

To accommodate any unequal surface of the ice, all the sections of the table are mounted separately on spiral springs. If any projection is frozen to the ice in any spot, the section of the table on which this projection will rest will sink lower than the others and so prevent the sheet of ice from breaking. It sometimes happens that one or more of the ¼-in. brine pipes become blocked and no ice forms on the 1-in. drop pipe. When this happens an imperfect sheet of ice will be made on the grid containing the blocked pipe. In a case of this kind, the separate sections and the springs prevent the cracking of the entire sheet.

The table at the plant being considered is divided into 30 sections 22 in. by 44 in. and 10 sections 22 in. by 22 in. This provides for each sheet or plate being cut into thirty 300-lb. and ten 150-lb. cakes. Just why the tanks were made for this size is not known, but the one-half cakes are readily disposed of.

With the table in its vertical position the grid and ice is lowered until it rests on the heavy supports provided. Then the inlet and outlet openings of the header are connected to the lines for the warm brine which is used for thawing. This brine is in a separate system, having its own receiving tank and circulating pump. The pump is steam driven and the exhaust steam is used for the heating of the brine.

The drop pipes are thawed loose in about a minute and the grid is raised, leaving the ice on the table.

The table is then placed in its horizontal position and the ice is sawed. The saw is motor operated and the cutting of the ice is a simple and rapid operation.

In squaring up the ends of the plate of ice there is always several hundred pounds of irregular shaped scrap ice that cannot be delivered to the vault. This scrap and all broken or otherwise imperfect ice is thrown into a tank that contains the water that is to be used in filling the compartment that is being emptied. By thus utilizing this waste ice, the temperature of the filling water is often as low as 45 or 50 deg.

The filling tank is also furnished with coils through which brine can be circulated to cool the water as low as possible before pumping into the freezing tanks. These coils were disconnected several years ago for some reason unknown to the writer. A small motor-driven centrifugal pump is used to take the water from the filling tank and discharge it to the freezing tanks. The regular service water of the plant can be used in case there is a reason for not using the water from the filling tank.

When the seven grids have all been pulled from a tank, the drain valve is opened and the sediment is allowed to pass to the sewer. At regular intervals the tanks are given a thorough cleaning and the sand that collects at the bottom is removed by means of shovels and buckets.

Horizontal Ammonia Compressors

TWO general types of horizontal compressors are available, those with valves and cages carried in the heads, and those with valves located in the cylinder. In either case the compressor is usually double-acting for larger capacities as this reduces the diameter of cylinder needed, and is one reason for using the horizontal arrangement.

Valves in the head are usually set at an angle and the ends of the piston made spherical, the object being to reduce clearance, and thus give a greater capacity

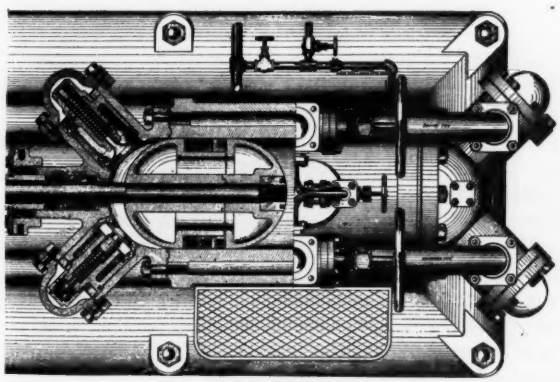


FIG. 1. HORIZONTAL SECTION OF HORIZONTAL COMPRESSOR WITH VALVES IN HEADS

per stroke for gas. This will be of special advantage if there is liquid mixed with the gas, as the liquid will evaporate before any new gas is drawn into the cylinder.

This is somewhat offset by two effects: the spherical ends of cylinder and piston present more surface than would flat ends, and this results in increased transfer of heat from the hot compressed gas to the cooler incoming gas, which, in turn, reduces the weight of gas admitted per stroke. Also the piston has less contact with cylinder walls than would one of the same length with flat ends, hence is less cooled by the water-jacketed cylinder walls, and gives a shorter interval between contact of the walls with hot discharge gas and cool suction gas. Both effects tend to heat the incoming gas and reduce capacity.

The compressor with valves in the cylinder, on the other hand, will have larger clearance, but will have a

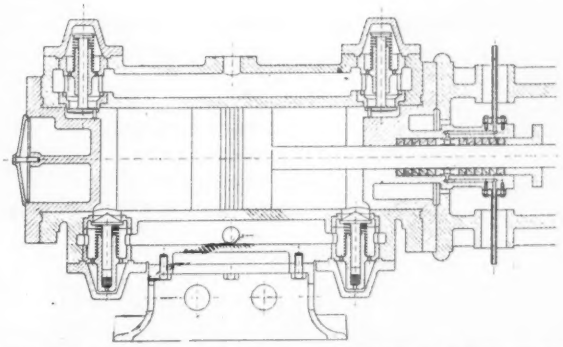


FIG. 2. VERTICAL SECTION OF HORIZONTAL COMPRESSOR WITH VALVES IN CYLINDER

long piston with flat heads, these conditions having the opposite influence of those discussed for the valve-in-head type. Also, by having admission valves above and discharge valves below, the incoming gas will not sweep over the exhaust valve surfaces to so great an extent as when both are in the head, hence heat interchange will be reduced. Liquid will also tend to be more fully discharged at each stroke, where the discharge valves are in the bottom of the cylinder.

Mechanically, the valves-in-head results in a simple cylinder casting and complex heads, while the valves-in-cylinder give simple heads and a complicated cylinder casting, but piping can be simplified in the latter type, since admission and discharge chambers are a part of the cylinder casting, and one pipe connection each will serve for each. Heads are easily removed for inspection of the cylinder and without disturbing pipe joints. It is also somewhat easier to devise methods of preventing a valve from dropping into the cylinder in case a stem breaks, although this is safeguarded by most designs of valves in the heads.

In either type, using light valves which permit of high rotative speed will give added capacity for a given size cylinder, but it is somewhat easier to use the light disc valve when the cages are carried in the cylinder. When the cylinder heads are simple, it is possible to use the crank-end head as a fitting surface for centering the cylinder with the frame and bored guides as in steam engine practice, giving greater convenience and accuracy in assembling. But placing the stuffing box inside the frame makes it less accessible for keeping the packing and cooling system in adjustment, and reboring of cylinders is more difficult by the complication of ports and cage openings.

Choice should be made after considering carefully the advantages of each type and comparing these also with the advantages of vertical compressors for the conditions of the particular plant in hand.

Keeping the Pumps in Service

STEAM LEAKING past the scored piston valves of a water pump supplying the sprinkler system caused the pump to become steam bound and, of course, inoperative. Inspection showed the valve cylinder was worn so much as to necessitate replacement. As it would require weeks for the manufacturers to ship the new parts, however, it was decided that if the pump was

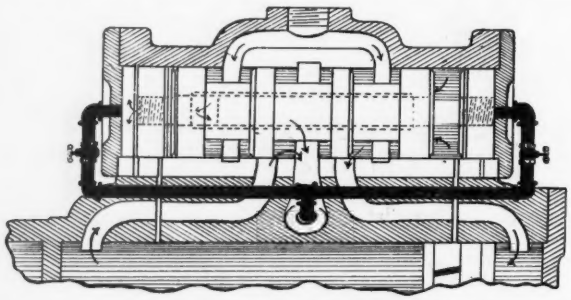


FIG. 1. DIAGRAM SHOWING METHOD OF RELIEVING STEAM

to remain in service some way must be found to release the excess steam pressure.

The cylinder ends, therefore, were drilled and tapped for ⅜-in. pipe as shown in the accompanying illustrations and the excess steam was delivered to the exhaust heating the feed water. Valves were placed in the line in order to allow only the exact leakage of steam past the piston valves to escape to the exhaust.

FIG. 2. PHOTOGRAPH SHOWING PIPING CONNECTED INTO EXHAUST LINE

This arrangement permitted the pump to work continuously and without attention until the new parts arrived and a shut-down—serious in case of fire—was prevented.

JOHN H. SCHALEK.

Handhole Gasket Blowout

THE FOLLOWING accident occurred in a steam plant which consisted of the following apparatus: two vertical boilers of the Manning type and a Westinghouse vertical engine.

Owing to lack of room, the engine was located practically in the boiler room, being only 120 ft. from the boilers, with no partition between. A partition would have prevented free access to the engine, and as the engineer at times also did the fixing it would have been an inconvenience. The engine, after being purchased, was found to run in an opposite direction from the line shaft to which it was to be belted. It could have been changed to run in the proper direction by purchasing new parts for the governor; but as money was scarce at the time, it was decided to get along with it as it was until the time came when proper changes could be made.

So the master mechanic made the following arrangement which proved quite satisfactory as far as carrying the belt in the proper direction was concerned. Two idler pulleys were placed, one above and one below the driving pulley and the belt carried around the pulleys as shown in Fig. 1. The belt was a three-ply

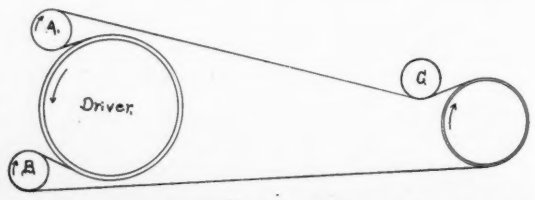


FIG. 1. DIAGRAM ILLUSTRATING ARRANGEMENT OF BELT AND IDLERS

leather, 25 in. wide and about 110 ft. long. An idler, C, was put on to take up slack and prevent slipping.

Because of the dust and ashes in the boiler room, and to prevent accident, a partition was built around the pulleys with doors in front of the top and bottom idler pulleys so as to render the bearings of these pulleys accessible. These bearings ran pretty warm and required frequent inspection to prevent overheating.

Trouble had been experienced with a new lot of handhole gaskets in not being able to keep them tight. Although care was taken when putting on new ones to see that the handhole plates and boiler plates were frequently smooth, they could not be tightened sufficiently to prevent leaking. The gaskets were of the ordinary kind with cloth center and cloth back.

On the day the accident happened, boiler No. 1, Fig. 2, was shut down in the morning for cleaning, and the load not being very heavy, was carried by

No. 2. As the engine had been running for some time, the bearings on the idler pulleys were giving considerable trouble by running hot, and the doors in front of them were left open to permit of frequent inspection. After cleaning No. 1 boiler and filling with water, the gaskets on the handhole plates at A and B, Fig. 2, which had been taken out for internal inspection and washing, were leaking. Time was short, however, and as the boiler would soon be needed for the afternoon load and, thinking the rubber in gaskets would soften up sufficiently after the steam was up to stop the leak provided the nut on the handhole plate was followed up, the boiler was steamed up and by following up on nut the leak was nearly stopped. After cutting the boiler in on line with the other one and running for about an hour, the gasket on the handhole plate at A, which had been renewed, blew out, filling the boiler room with steam. The hot water poured out around the handhole plate as fast as it could get out, being forced out by the full boiler pressure of 145 lb. The doors in the belt guard were open and being in direct line with the handhole, the belt received the full force of the water. By referring to Fig. 2 it will be seen that all the water striking the belt at C was carried

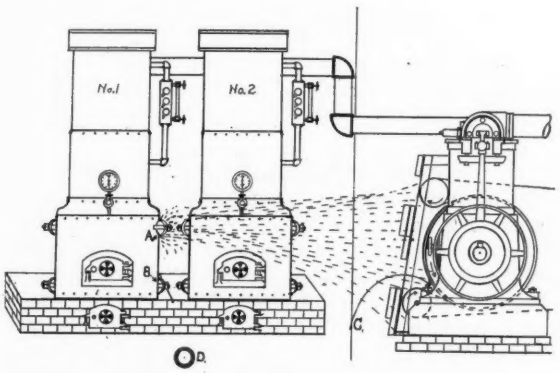


FIG. 2. BOILERS AND ENGINE, SHOWING BELT GUARD

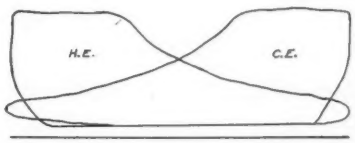
along with the belt and in going around the driving pulley was pressed into the belt, whereas the water striking the top pulley was thrown off. The engineer, being occupied with the feed pump at the time of the blowout and hearing the noise, made a run for the boiler room, thinking to close the doors, but upon stepping into the room, stepped into about 3 in. of water which had come from the boiler, but which had cooled off in the meanwhile, otherwise he would have been severely scalded. Realizing he could not get to the door in the belt guard to close them, he shut down the engine. Someone then held a board in front of the handhole to deflect the stream of hot water, thus enabling us to close the trap doors in front of the belt and to open the drain at D to drain off the water on the floor. The pump was kept going to keep up the water level in the boiler until the boiler was cut off the line, the fires drawn and the boiler allowed to cool off. An inspection was then made of the belt and it was found that every lap had started owing to the drenching it had received from the hot water. Anyone at all familiar with belts can realize the result, and as no facilities were at hand to repair it, it was sent back to the factory to be made up new.

While waiting for the return of the belt, new gaskets with wire insertion were procured and put in. The boiler was steamed up and although the gaskets were pretty stiff owing to the wire insertion, they finally tightened up and no further trouble was experienced. Nothing but wire insertion gaskets were used in that plant afterwards, as one experience with the ordinary kind was sufficient. The arrangement of idler pulleys shown in Fig. 1 was done away with soon after, the engine being belted direct to an alternator.

LEON L. LOLLARD.

Defective Indicator Diagram

WHILE INDICATING an engine some time ago and after securing a few diagrams, I noticed a defect in the compression line of the crank end of one of the cards. This is shown herewith. It did not occur in all of the cards,



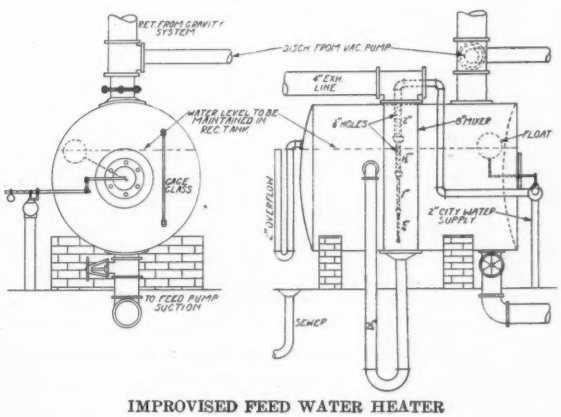
DEFECTIVE DIAGRAM DUE TO INDICATOR CORD

only occasionally. After some search, however, I located the trouble. The cord from the reducing motion to the indicator, would, when in motion, run over the cord when it had previously wound up on the bushing of the reducing motion. This would give the indicator drum which carries the paper an irregular motion. After I had the line running properly again, the cards came out all right.

TOM JONES.

Improvised Feed Water Heater

THE FOLLOWING description of an arrangement which was installed by our chief engineer when our closed heater for handling the boiler feed failed, may be of interest to readers of Power Plant Engineering. While



IMPROVISED FEED WATER HEATER

originally intended as a temporary measure, the installation has been so effective that it has been made permanent.

The heating system was partly a gravity return system and partly a vacuum system. Both returns were delivered to a large receiver which was also used as a

storage tank for feed water. When the regular boiler feed water heater failed, this receiver or storage tank was connected into a heater. The accompanying illustration shows the arrangement after the changes were made.

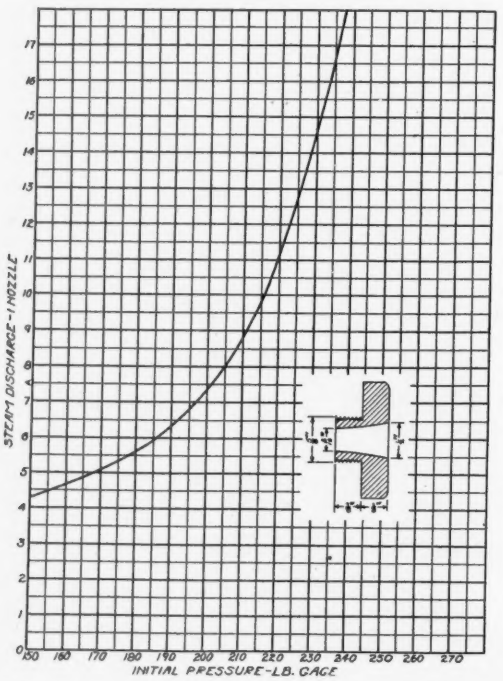
As will be noted, the principal feature of this improvement is the mixer that was made of 8-in. pipe about 6 ft. long, with a perforated water nozzle centered on the inside. The number of perforations is such that the combined area of the holes is equal to the area of a 2-in. pipe, the holes being drilled ⅛ in. A special flange was made and riveted on the head end of the tank with a special housing for a balanced float valve which was fitted in the city water line.

Since putting this system in operation, we have not had any trouble and as the plant operates 24 hr. a day we are always assured of enough exhaust steam for use in the mixer. A feed water temperature of 187 deg. F. has been attained with a back pressure of 3 lb.

WALTER D. SMITH.

Steam Used by Soot Blowers

SOME PRACTICAL tests have lately been made in a Western boiler plant to determine the quantity of boiler steam used for blowing the soot off the boiler tubes. In this particular plant, this operation is accomplished by the use of a modern type of soot blowing apparatus, eight units being installed in each water-tube boiler.



SECTIONAL VIEW OF SOOT BLOWER NOZZLE USED AND CURVE SHOWING RELATION OF STEAM PRESSURE TO DISCHARGE THROUGH ONE NOZZLE

Each of these eight units consists of a 2-in. calorized pipe header which is revolved by means of an external chain wheel, through a certain given arc. Each unit contains 22 small brass vent nozzles screwed in a line along the 2-in. header, through which the steam is blown between the rows of tubes.

In order to determine the quantity of steam used a number of the venturi nozzles were fitted up with pressure gages and steam delivered through them to a body of water. By weighing the body of water before and after the tests and measuring the time of steam flow, the following results (average) were obtained:

QUANTITY OF STEAM PASSED THROUGH NOZZLE AND ELEMENT

Initial Steam Pressure lb. Gage	Discharge, Per Nozzle	Lb. Per Min. Per Element of 22 Nozzles
150	4.34	95.48
200	6.44	141.68
233	16.26	357.72
235	16.67	366.74

It is common practice to operate these soot blowers once a day and allow each unit to blow 3 min. Hence, the steam used per day on an 8-unit boiler would be 3 × 8 or 24 times the foregoing figures.

C. C. BROWN.

Why the Lights Flickered

ABOUT 15 YR. ago the writer had an experience with flickering electric lights that may be of interest to engineers who are now having or may have similar trouble in the future.

The engine I was operating was of the flywheel governing type, directly connected to the generator. The electric lights flickered and I was at a loss as to how to remedy the defect. When new, the engine operated satisfactorily, without causing flicker; therefore I knew, of course, that it would do so again if properly repaired or adjusted.

I finally took the matter up with the manufacturers of the engine, who told me how to adjust the governor to make certain that it was in the right position, and to be sure that it was not sticking.

Several communications passed between us before they began to inquire about the piston valve. This valve, which had solid heads, had become badly worn and was leaking steam in every position. As soon as a new piston was obtained and the valve housing rebored to prevent further leakage, the flickering of the lights stopped.

N. G. NEAR.

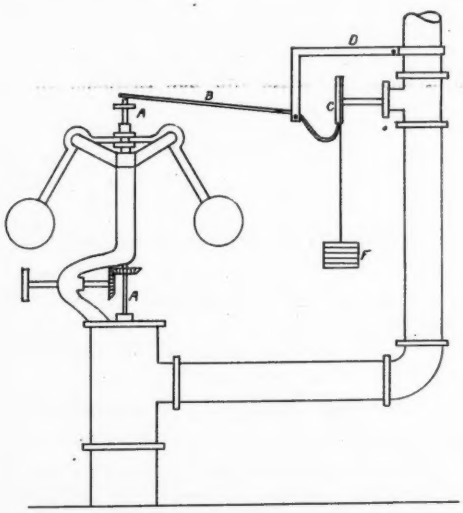
Use of Pipe Columns as Struts

IN THE article regarding the use of pipes as columns in the Jan. 15 issue, I note that the author states that he is unable to find the radius of gyration of pipes listed in any hand book. For his benefit, I wish to state that this property as well as the moment of inertia and the section modulus for standard, extra heavy and double extra heavy pipe are all listed in the hand book issued by the Cambria Steel Co. The latter properties are useful in figuring the stress and the deflection of pipe when placed in a horizontal position. I find it desirable frequently to check the probable deflection or sag when circumstances necessitate placing supports farther apart than usual.

R. E. BUFFINGTON.

Homemade Governor Safety Valve

THE ILLUSTRATION is that of an engine governor which has no safety arrangement. If the governor belt should break or come off the governor would stop revolving, the balls would be drawn in due to the action of gravity and valve stem AA would rise. This, of course, would open the valve wide, allowing engine to race. To prevent this I have devised the automatic stop shown. A bracket, D, is clamped to the steam pipe and is bent to hold lever B. A ¼-in. square notch is cut in throttle wheel so that this notch will be at bottom of wheel when open. A weight, F, is suspended by a small chain which makes a few turns around the flat throttle wheel. When the throttle is open and weight wound up, lever B catches into the notch on the wheel at the bottom.



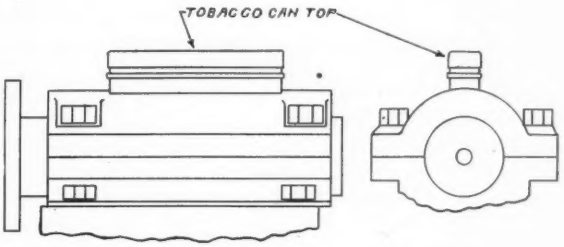
HOME-MADE ENGINE STOP

When the governor stops, valve stem A rises and pushes up lever B, and of course the weight closes the valve immediately. Of course the valve stem should be packed so that the weight will not be made ineffective.

Material for making this can be found around almost any plant as junk and, although not perfect, might some day save a wrecked engine and is decidedly better than nothing. A. WALDRON.

Improvised Oil Cup

A BETTER oiling arrangement was needed for the grindstone, as the small hole through the top of the box frequently became plugged, and the heavy stone needed a better source of oil to its bearing than was afforded by the opening in the box cap. The sketch shows how an old tobacco can was cut and soldered to the cap. This allowed a small amount of waste to hold oil to be used, as well as providing at the same time a much needed cover. It did not take much time to stick it on, and



OIL CUP MADE OF AN OLD TOBACCO CAN

there might be other circumstances where the idea could be used by someone else with good results around a similar difficulty. FRANK W. BENTLEY, JR.

First Aid for a Leak

WHILE the kink mentioned herein was told at a garage, it may not be generally known, therefore it is worthy of being heralded, because many of us use the automobile and all of us are more or less interested in first aid for leaks at some time, from various sources. One of the most valuable and inexpensive things for every motorist or anyone who must contend with a leak is a bar of ordinary laundry soap. It can be whittled with a pen knife and the shavings crushed into a putty to repair leaks in the gasoline or oil lines. The soap putty may be held in position by strapping it with common cloth tape.

Of course, this is a temporary repair, and temporary repairs have no place in engineering life when it is practicable to avoid them, but while waiting until real repairs can be made you may rest assured that neither oil nor gasoline will cut through the soap.

J. B. DILLON.

A Simple Well Kink

THE CHIEF engineer of a public utility company received the following telephone message from the operating engineer on the night shift: "Chief, the air compressor gage on the well is showing 150 lb. pressure and 2 hr. ago it was only 100, which I observed was 40 lb. more than the usual working pressure. The amount of water coming from the well is but little. Also we are now short in the reservoir, and by morning we will be out of water."

The well is 800 ft. deep with 280 ft. 1½-in. air line inserted into the well, the last 18-ft. length being

perforated with somewhat over 960, 3/16-in. holes. It has a coupling and plug at the bottom end of the pipe so as to compel the air to ooze out of the small holes. The water rises to the surface under its own head but not in sufficient quantity to supply the needs of the plant.

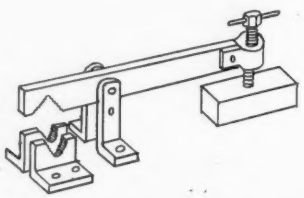
No time was lost in placing a small duplex pump by the side of the well and connecting the suction of the pump to the air line of the well, and then after running the pump at a slow speed for about 15 min. trash and scale, which proved to be the obstruction inside of the air line of the well, began to come out, and after about an hour's pumping all of the scale had been sucked to the surface.

Air was then placed back on the well, and it flowed as freely as ever before. H. W. Rose.

Powerful Grip Pipe Vise

For a homemade pipe vise requiring but few tools to make and very little material, it would be difficult to find anything simpler than that shown in the accompanying sketch.

The two stationary jaws are simply pieces of 5/16 by 2-in. steel bent at right angles and the V-jaws cut

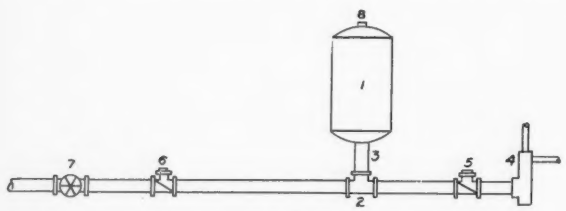


SHOWING CONSTRUCTION OF PIPE VISE

in with a hack saw. The frame of the moving jaw is made of two pieces of 5/16 by 1 in. or thereabout. The long leverage of the moving jaw gives great gripping power. The end of this jaw is bent around in a small circle and tapped out for a bolt. Chas. H. Willey.

Homemade Boiler Compound Feeder

To make this boiler compound feeder, I took two reducers, each 2½ in. to ¾-in. Then I took a 2½-in. pipe 6 in. long, cut threads on both ends and screwed on the reducers as shown at 1. I then cut the feed line



COMPOUND FEEDER MADE FROM STANDARD FITTINGS

as at 2 and put in a ¾-in. tee; in this I screwed in a ¾-in. nipple 3 in. long, as shown at 3.

The boiler is of the locomotive type equipped with two injectors, 4 being the injector; 5 and 6 are check valves; 7 is a globe valve; 8 is a ¾-in. plug which is removed and a funnel inserted for filling.

I have been feeding a graphite compound with good results, using about two pints of this compound a day. The boiler furnishes steam for a 75-hp. engine.

Edward Moehl.

Cause of Pump Trouble

Some time ago I purchased a new Morse pump and before placing it in the hole and connecting it up to the return line I connected it to the steam line to try it out and found that it operated satisfactorily; then I placed it in the hole and connected it up to the return water line and it made only one stroke and then failed to operate.

When I began to examine it again I found the trouble was that a piece of gravel had lodged in the steam port and this was preventing the pump from operating. After removing the piece of gravel and then connecting it up again it operated perfectly.

Garnett Wilson.

Small Emergency Clamp

A small, light clamp was needed to hold together temporarily some pieces of a job for a compressor. A toolmakers' clamp was too light and the smallest C clamp on hand was too large.

A compromise was effected by using the jaw of a 6-in. trimo, the thumb nut, and a washer which just slipped over the shank of the jaw.

It made a practical substitute for the real thing until the plates were laid off and drilled. In a pinch

DETAILS OF EMERGENCY CLAMP

it was a good makeshift for the unavailable tool, which is many times the case.

F. W. Bentley, Jr.

Heat Insulating Material

Used kieselguhr, or Fuller's Earth, which is ordinarily discarded after it has served its purpose as a filtering medium, can be used as the base of an excellent heat insulation. The following mixture has been extensively used for covering steampipes and other hot surfaces and has been very satisfactory:

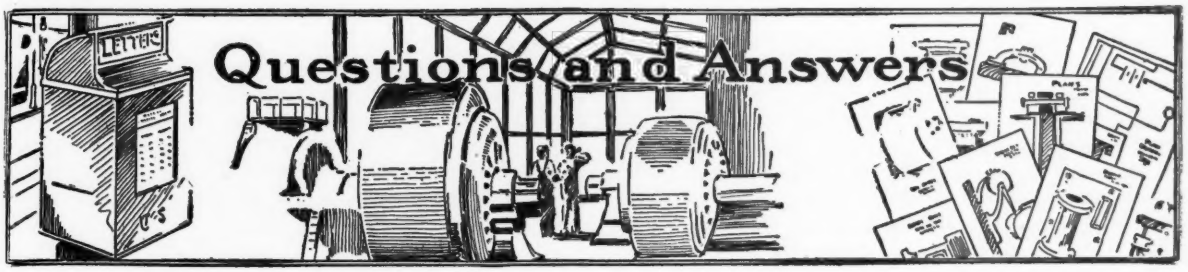
Used kieselguhr, 10 sacks; new kieselguhr, 1 sack; asbestos magnesia cement, 1 sack; slacked lime, 1 sack.

This, when plastered on and allowed to dry, forms a smooth, hard insulating material that is durable and lasting.

C. C. Brown.

President Harding has directed the Secretary of State to start negotiations with Great Britain for a treaty under which the proposed waterway may be built. In the meantime, it is generally understood that no legislation will be reported out of Congressional committees on this subject.

Few champions "get there" without deserving it.



Non-Return Valves Chatter

IN THE plant where I am employed we have four 150-hp. horizontal return tubular boilers which generate steam at 140 lb. gage pressure. Each boiler is connected in the same way to a 40-ft. header 10 in. in diameter, through 6-in. branches. Each branch is equipped with one gate stop valve and one automatic non-return valve. The header supplies through other 6-in. branches three uniflow engines, one 450 hp. and two 175 hp. The boilers are set in a row and numbered left to right from 1 to 4. Ordinarily two are used at a time. When we use 1 and 2 the non-return valve on No. 2 keeps hammering up and down with every stroke of the engine, and when we use Nos. 3 and 4 the non-return on No. 4 does the same thing.

It makes no difference which engines are running, the valves will chatter with any one or two of them carrying the load. I have noticed, however, that the hammering seems worse when we are running with a light load.

Would appreciate suggestions from readers of Power Plant Engineering as to how I might overcome this difficulty. L. K.

Setting for Burning Fuel Oil

IN THE issue of Jan. 15, under the above heading, S. I. C. submits a sketch of a 75-hp. horizontal return tubular boiler, together with the statement that, although burning oil having a heating value of 19,000 B.t.u. per lb., the evaporation obtained is 10 lb. of water per pound of oil, and that the setting is air-tight and the boiler free of scale.

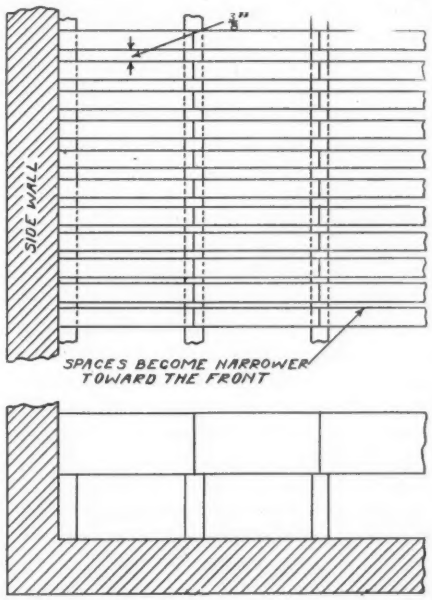
The cause of this low evaporation undoubtedly lies in the oil-burning equipment. Not that the burner is not properly atomizing the oil, but that complete atomization is just one step in the right direction. The next step is to introduce preheated air, resulting in complete combustion.

There is a patented furnace on the market which does it. Each furnace is specially designed to meet the existing conditions, therefore the manufacturers are able to guarantee high efficiencies.

From the information given by S. I. C., I am sure that with this furnace an equivalent evaporation of 15 lb. water per lb. of fuel (78 per cent efficiency) could be obtained. RICHARD T. HOUSEMAN.

REFERRING TO S. I. C.'s question on Setting for Burning Fuel Oil, I believe he would be better off if he took out the grates altogether and laid a checkerwork of bricks directly on the ashpit floor. Spaces should be ⅜ in. wide at the rear but should decrease gradually towards the front, as shown in the accompanying sketch. Ashpit doors should be bricked up so that air can enter only under the checkerwork. The bridge wall should be cut down flush with the checkerwork at the back. The spaces in the checker may need a little adjusting to get an even flame without white spots, which show too much air. The uptake damper should be closed until the flame in the furnace shows a light orange color and until there is a faint gray haze at the top of the stack.

S. I. C. does not say what burner he is using or how much power he is developing; but for any reasonable



SUGGESTED CONSTRUCTION OF CHECKERWORK

rating on the boiler, and with the checkerwork lowered as suggested, the furnace volume should be ample.

If the flame sweeps well past the bridge wall it may pay to remove it and carry the bottom checkerwork further back to where it tails out. The burner should be set to point slightly down, but not enough to strike hard on the checker, or "tears" of unconsumed carbon will form.

Once the furnace is correct the main thing to watch is the draft, as without a fire on the grates it is too easy to obtain an enormous excess of air. The uptake damper should be closed until the fire shows a clear light orange color, and if there is only one boiler in use, until a light grey haze shows at the top of the chimney. If there are several boilers, watch the stack and equalize the air to the boilers with the uptake dampers so the fires all have the same color.

H. D. FISHER.

S. I. C. COULD improve his present conditions by removing the grate bars and dropping the level of his checkerwork to about 14 in. above the bottom of the pit. His checker work should not extend completely across the furnace but should flare, the narrowest part being under the burner and the widest about halfway to the bridge wall. The burner should not be over 6 in. above the checker work.

An analysis of flue gas will tell whether or not too much air is passing through the furnace. About 14 per cent should be realized as the CO_2 content. If the damper in the flue is adjusted according to the load and just closed enough so that no smoke is made when the burner is working properly, the efficiency of the boiler should be increased. Almost any boiler manufacturer today will give an engineer a sketch of an oil burner setting and S. I. C. may be able to get in touch with his boiler man and receive much valuable information. WM. F. O'REAGAN.

Scale and Distorted Tubes

I READ the question on tube distortion in the Dec. 15 issue and Mr. Swetnam's answer which was published in the issue of a month later, and while the explanation is both possible and suitable, I feel that the phenomenon might be due to some other cause. For this reason I am writing this, and I wish it understood from the first that this is not in any way an attempt to refute the other answer.

D. T. McA., who sent in the query, said, I believe, that there was no scale, but I wish to suggest that the trouble might easily have been caused by scale in spite of this fact. When a leak appears in a tube it is natural that scale should form there thicker than anywhere else. The scale stops the leak, but as it has a different coefficient of expansion from that of the tube metal, it will cause the tube to swell when it is heated or cooled suddenly. Eventually a rupture would result, which might cause considerable damage.

The fact that there was no scale present I account for by the fact that a change of water will often remove scale. As far as I have been able to find out, it seems that the use of soft city water will not only remove scale, but will sometimes cause pitting of the metal when the scale is all gone. DUKE BARTON.

Consuming Less by Using Larger Drops

IN THE Jan. 15 issue, on page 140, I find an article by A. C. Waldron concerning trouble he had had with pump lubrication.

I believe I can explain the reason why his pump did not work while feeding small drops, but did when using about half the quantity of oil, in large drops. I find that the better chance cylinder oil is given to mix with the steam the more effective it will be. The small drops fed only ran down the inside of the steam pipe without giving the steam a fair chance of catching and spreading the oil and thoroughly mixing with it as it should. They lubricated only a part of the desired surface, whereas the larger drops were caught and spread by the steam, giving the desired lubrication.

I once had the same trouble with a high speed engine, only I went a little farther and moved the lubricator connection about 4 ft. away from the cylinder and made a nipple that extended inside the steam line about 2 in. Feeding the oil out in the steam and moving the feed connection farther away gave the oil a pretty good chance to mix with the steam and ended my trouble, cutting down to half the oil that I previously used. J. E. STEELE.

What Causes Leaky Tubes

ON PAGE 144 of the Jan. 15 issue of Power Plant Engineering, C. G. Harden has an article which is an answer to an article in the Nov. 15 issue.

I certainly would not approve of his setting that he shows in Fig. 2. The combustion chamber is entirely too small; the space will be filled with ashes in a short time, and it does not give room enough for the combustion of the gases.

In Fig. 1, to my mind, the path of the gases of combustion is exaggerated; I am of the opinion that it will hug the boiler more, surely the hottest gases will.

There does not seem to be any reason why the water will not conduct the heat away from the head the same as it does away from the bottom of the boiler.

I have been in charge of different horizontal return tubular boilers for the past 16 yr. and so far have had no trouble with leaky tubes, the setting always being the same as in Fig. 1. Therefore I cannot see why the setting would cause the trouble, possibly the tubes were not right at the start. F. C. E.

Locating Obstruction in Heating System Return Line

WE HAVE several return lines of our heating system stopped up. How can the obstruction be removed? Could the desired result be effected by making a live steam connection with the return line and blowing live steam through? O. B.

A. Should the stoppage of flow be due to oil or soft sludge, the method suggested would probably produce the desired results; but, if the pipe is blocked with a chunk of scale or waste at some one particular point, as is more likely the case, it is questionable whether or not any pressure which could safely be applied would remove the obstruction.

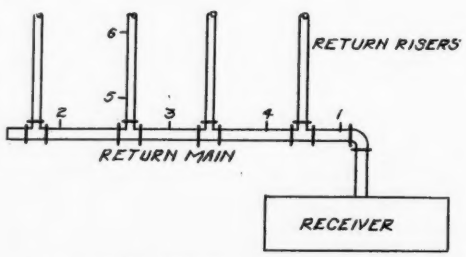


DIAGRAM SHOWING RETURN PIPING

Assuming that the trouble is localized and that the return piping is sufficiently large, is not scaled for any great distance and is not air bound, the following method of procedure may be suggested.

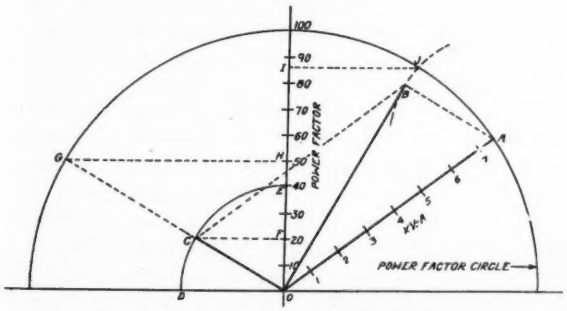
Referring to the accompanying sketch, tap a small hole in the upper side of the return main at the point marked 1, just above the receiver. If water spouts from

this hole, the indications are that the pipe is full of water above this point and that the obstruction is below. It will be an easy matter, then, to break the joints below, take out the section and clear it. If water does not spout from the hole, the obstruction is farther along the line. Next tap near the end of the main. If it spouts, the trouble is between it and the first hole, in which case the obstructed section may be found by tapping back a section at a time until a dry tap is found. The obstruction will be just ahead of the last hole. Each hole must be temporarily plugged after tapping to prevent escape of the water. If the end hole on the main is dry, the trouble will be in one of the risers. An obstructed riser will be comparatively cold to the touch and the faulty one may be located in this manner. When one is found, the obstruction may be located by drilling it, starting at the bottom and working upward until a spouting hole is found. The obstruction will be directly below the first hole that spouts.

Power Factor Correction

IN REFERENCE to an article, "Power Factor Correction by Synchronous Motors," which appeared on page 1174 of the Dec. 15, 1920, number of Power Plant Engineering, I would like to know why the kv.a. vectors are carried beyond the power factor circle in the various figures. It seems to me as though all kv.a. vectors should terminate at the power factor circle, otherwise an error is introduced since at unity power factor kv.a. equals kw. Also in Fig. 3, if a center were taken at the intersection of line OA and the power factor circle, instead of at A, would not the power factor be greater, since the amount of corrective kv.a. shown would intersect the power factor circle at a higher point?

Again, in Fig. 3, if some of the kw. load were dropped and the motor kv.a. given more lead, would



Rule 1. The length of any radial line represents KVA. (Scale on line OA)

Rule 2. The projection onto the vertical of the point where any radial line or its projection crosses or intersects the P.F circle represents the power factor. P.F. circle may be any radius so long as this radius is unity, i.e. divided into 10 or 100 equal parts.

Rule 3. The length of the vertical to any point which is a horizontal projection from the end of any KVA line represents KW (power) to the scale on line OA. In other words KVA on vertical equals KW.

FIG. 1. VECTOR ILLUSTRATING LOAD TO BE CARRIED TO GIVE MAXIMUM POWER FACTOR CORRECTION

not the system power factor be raised due to the fact that there would be a greater angle between the original system kv.a. and the motor kv.a.? I realize that the article states that "adding mechanical load to a synchronous motor enables it to give more correction," etc., but I assume that to apply only up to the rated kv.a. of the motor, such as is assumed in Fig. 3. A full explanation of these points would be appreciated.

G. R. M.

A. In applying a power factor circle to these vector diagrams, its radius may be any length at all, as it is used solely for determining the angles and cosines of these angles. Its radius has no relation to the amount of kv.a. or kw. on the system; its radius, however, should be easily divisible into 10 or 100 parts for ease in scaling. The length of the lines OA and OB, etc. on the other hand must accurately represent the value of kv.a. and of course if any line be projected onto the vertical, then the length of this vertical projection represents kw. or kv.a. at 100 per cent. The line OA can terminate at the power factor circle if desired or

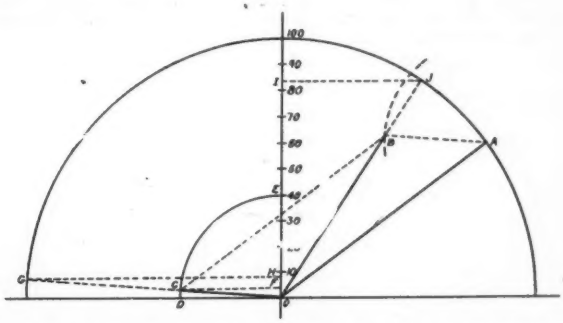


FIG. 2. VECTOR ILLUSTRATING EFFECT OF DROPPING SOME OF THE KW. LOAD

the radius of the power factor circle may be increased to the length of the line OA, giving the diagram the appearance of Fig. 1 shown herewith. The result is exactly the same in either case.

Now it will be seen that if the radius of the circle DCE is duplicated at the intersection of the line OA and the power factor circle, the result is the same as the original Fig. 3 (Dec. 15, 1920 issue), because the line CA represents values of kv.a. and the power factor circle determines angles; the two must be kept separate and cannot be mixed.

Figure 2 herewith represents the condition stated in the second paragraph of the inquiry; i. e., dropping some of the kw. load and giving the remainder of the load more lead. This will, of course, increase the angle between the system kv.a. and the motor kv.a. as is represented by the angle AOC. But draw the resultant OB and then project its intersection at the power factor circle onto the vertical as represented by line IJ. This is now less than 85 per cent; and any other angle of line OC will result in less correction.

Perhaps the statement that "adding mechanical load to a synchronous motor will enable it to give more correction than if it is run merely as a condenser" should be qualified by giving a limit to the mechanical load, which limit is obtained by the method outlined in Fig. 3, (Dec. 15, 1920). For instance, in this case a mechanical load of 150 kw. at 50 per cent will give a maximum correction, although the kv.a. capacity of the machine is 300 kv.a. In other words, 180 kw. at 60 per cent or 270 kw. at 90 per cent or 120 kw. at 40 per cent or 60 kw. at 20 per cent will not give as much correction as 150 kw. at 50 per cent.

V. H. TODD.

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Laying Plans

Following the path of least resistance, the chief engineer's work in nearly any power plant has a tendency to become a matter of routine, not necessarily in the sense that he has the same problems come up for his solution day after day but he usually finds that by following a certain routine through the work of the day he accomplishes most with the least amount of effort.

Upon arrival at the plant in the morning he usually runs the rounds of the equipment under his care to see whether or not it is operating properly and that the force is all on duty, and to give final instructions on the work of the day. Attention to incoming mail and correspondence may take the second period, followed by a study of the previous day's records.

Any of this work may be interrupted by the necessity of giving special instructions on some particular work or repairs, by calls of salesmen or a hundred and one other duties that demand his attention. What wonder then that in a great many cases the chief engineer's work becomes principally routine which he is of necessity compelled to follow rather than that of planning and directing which should be the work of the executive?

Notwithstanding the many and urgent demands upon the chief engineer's time, if he wishes to improve economy in his power plant he must devote a certain amount of time to planning future work. Many industries have in their organizations planning departments that carry on investigations and make recommendations affecting organization, routine, equipment and conditions governing the economy of production. In the power plant, this work usually falls upon the chief engineer, if it is done at all.

Throughout the course of every day, ideas for the improvement of the plant will flash through the mind of any thoughtful engineer; it may be a passing fancy which would prove impracticable or uneconomical, or with proper development the idea may result in a marked saving to the plant. To pass up an idea as worthless before it has been proved valueless either by logical reasoning or actual experiment is not giving justice to the owners of the plant. Time at the moment may not permit a reasonable consideration of the idea; but with a notebook handy the thought can be jotted down for full consideration at a more propitious time.

Towards the close of the day, when the routine has been cleared out of the way, the progress of the work about the plant is known and when detailed plans for the next day's work must be made, is probably the most convenient time for taking a longer look ahead and considering possible changes and improvements that have suggested themselves during the day.

No engineer who has given the matter any thought would go to the owners of a plant with a recommendation which he has not proved to his own satisfaction is worth while adopting. So when it becomes apparent that certain changes should be made, a plan to secure permission to make those changes should be laid out as carefully as you would plan to install a boiler. Don't for a moment think that, because every recommendation you have made in the past was adopted, your present ideas will be accepted without further consideration but make your investigations well in advance, collect all important data and arrange it in a logical order, then

present this material, with suggestions for carrying the work to completion, to the proper authorities for consideration. With such complete data on hand quick action should be secured.

A study of daily records should suggest certain tests that ought to be made in order to bring out possible improvements in operation. This study may also suggest the installation of instruments to supply needed data. The cost of repairs or time out of different machines may show need of replacement.

The human element is probably the greatest variable factor affecting the economy of power plant operation and as such the chief engineer must look after the welfare of his workmen with as much care as he would any important piece of machinery. Labor saving devices, safety guards, private lockers, wash rooms, lunch, reading and rest rooms, classes organized for instruction, occasional conferences to get the views of the workmen on changes or improvements needed, all can be used to improve human relations with consequent closer co-operation and higher plant economy. To put any change from the regular custom into effect requires planning, and this takes time; but if judiciously spent the hours required will bring greater dividends to the power plant than an equal time spent in any other work. Take time to do your planning even if it must be done at the expense of some routine work.

Refrigerating Mediums

As a refrigerating medium, ammonia has established and maintained a fairly firm foothold in this country. The great majority of plants engaged in the manufacture of ice and refrigeration, for whatever purpose, are equipped with ammonia compressors, condensers, etc.; comparatively few utilize carbon dioxide gas as a refrigerant.

In Europe, on the contrary, the CO_2 system has kept pace with the ammonia development and today the two are apparently about on a par. Within recent years the CO_2 machine has come to the front in the United States and may now be considered a serious factor in competition with ammonia compressor systems.

Obviously the choice of refrigerating mediums is dependent upon many factors and each may be said to have its place in the industry. Like any question where the exercise of judgment is required, there are things to be said on both sides. It cannot be arbitrarily stated that this system is better than that. The question has to be decided for each installation on its individual requirements.

Leakage of ammonia fumes into the atmosphere, even in comparatively small quantities, is dangerous to life, and on account of this danger incident to the use of ammonia apparatus, municipal governments in congested localities have, as a rule, passed rather stringent ordinances dictating just how such a system must be installed. As a consequence hotels, theatres, office buildings and the like are leaning toward the carbon dioxide system as carbon dioxide is relatively harmless even if present in the atmosphere in comparatively large quantities. Space allotted to refrigerating apparatus is usually rather inadequate for the purpose and this fact constitutes another reason why CO_2 machines are looked on with favor. The compressor itself requires less space and the condensor, being able to use copper tubing, can be installed in less space.

On the other hand CO_2 joints are extremely difficult to keep tight on account of the high pressures encountered and for this reason the piping must be kept down to a minimum, which means that direct expansion cannot be used to advantage.

The CO_2 system is one which requires, to a greater extent than ammonia, cold condensing water which may not always be conveniently available.

Power requirements per ton of refrigerating effect are inherently greater for CO_2 than for ammonia, a fact which presents a weighty argument on one side of this question.

In installing the refrigerating equipment for the Tivoli theatre in Chicago, whose heating and ventilating system is described in this issue, this question had to be answered. How it was answered and the reasons for this answer are told in this article.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

Storing Refrigerating Effect

Ice is, of course, the universal medium used for storing refrigerating effect, the reason being that it is capable of a large cooling effect per unit of weight, is easily handled and can be stored for considerable length of time. Where handling and transportation, weight and time are not factors to be considered, water or brine is frequently used. The refrigerating plant of the Tivoli theatre operates under these conditions. The storage facilities store refrigerating capacity for 7 hr. of the day to be used during the following 6 or 8 hr.

As arranged at present, about half of the reserve capacity is stored in a large mass of water, the remainder, in ice that is later formed on the expansion coils. There is one objection to this system and that is that as this ice begins to form on the tubes, the efficiency of heat transmission to the refrigerating medium is reduced and consequently the capacity of the plant drops off.

On account of this condition, the question of substituting a calcium brine for the water is now being given consideration. The advantage of utilizing brine as a storage medium, lies in the fact that the temperature may be reduced to a lower point without forming an insulating coating on the expansion coils. The effect of this system would be to maintain the maximum capacity of the refrigerating machine, although the efficiency would be reduced somewhat, as the suction pressure would have to be reduced. The decision reached on this point and a comparison of tests on the two systems should be interesting.

New Type Ingersoll-Rand Surface Condenser

IN THE design of the latest type of surface condenser recently put on the market by the Ingersoll-Rand Co. several features have been incorporated which make it radically different from former designs but directly in the line of improvement as indicated by an extensive series of investigations carried on by the manufacturer.

The first aim was to design the condenser so as to keep all the tubes uniformly hot on the steam side, thus reducing to a minimum the number of tubes required.

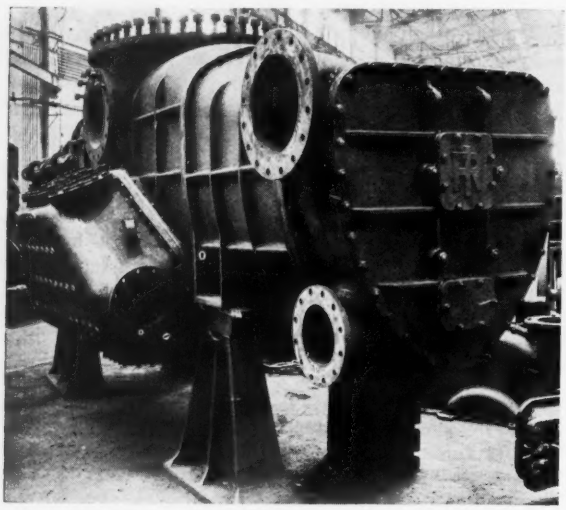


FIG. 1. INGERSOLL-RAND SURFACE CONDENSER SHOWING INLET WATER CONNECTIONS ON CONDENSER AND COOLER

To accomplish this the arrangement and spacing of the tubes is in stages such as to provide large flow areas at the exhaust entrance and great distances between rows to avoid sharp bends and pressure loss, thus giving an opportunity for the steam to flow freely to and over all tubes with slight loss of pressure and temperature.

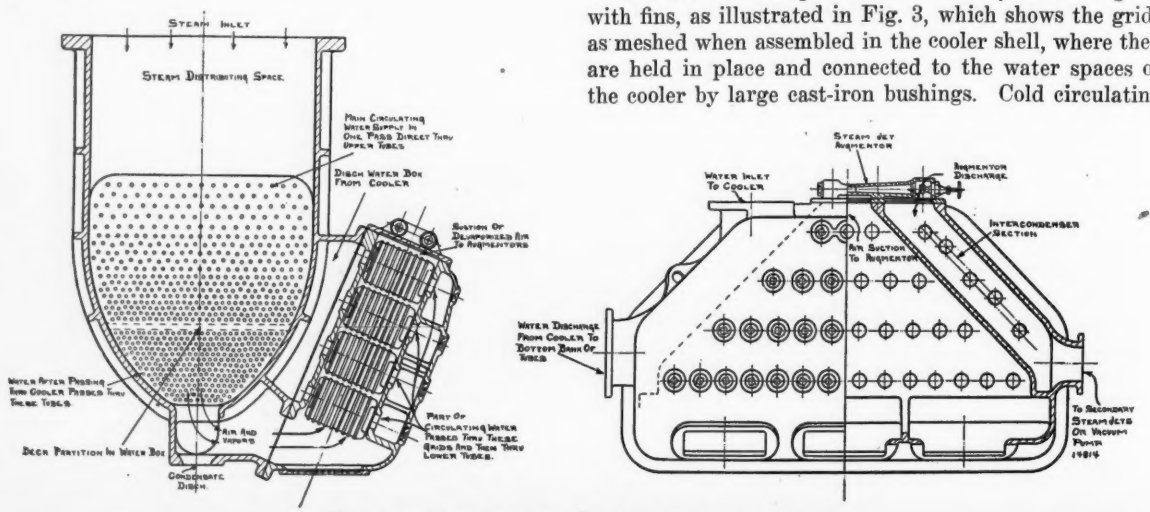

Steam Inlet
Steam Distributing Space
Main Circulating Water Supply In One Pass Direct Thru Upper Tubes
Discn Water Box From Cooler
Suction Or Dehydrogenized Air To Augmentors
Water After Passing Thru Cooler Passed Thru Tubes.
Air And Vapors
Deck Partition In Water Box
Condensate Discn.
Part Of Circulating Water Passed Thru Tubes Grids And Thru Lower Tubes.
Steam Jet Augmentor
Water Inlet To Cooler
Augmentor Discharge
Intercondenser Section
Air Suction To Augmentors
Water Discharge From Cooler To Bottom Bank Of Tubes
To Secondary Steam Jets Or Vacuum Pump

FIG. 2. CROSS-SECTION THROUGH CONDENSER AND COOLER

Another object kept in mind was the maintaining of velocities that will sweep the air ahead in the current of steam which is accomplished by arranging the tubes in staggered rows so that none is shielded or pocketed. The experiments which were conducted showed that this current is most effective in producing heat transfer in front of the tube, the side about 90 per cent active and the back about 75 per cent. In order to maintain these velocities throughout the depth of the condenser, not only is the spacing of the tubes less at the bottom than at the top but the shell of the condenser is made wedge- or heart-shape, terminating in a narrow slot-shaped outlet.

The object of this design is to maintain a homogeneous mixture of steam and air, and also to keep the temperature of the exhaust steam from falling until a large percentage has been condensed. Tests have shown that starting with approximately 92 deg. temperature there is no perceptible fall of temperature due to increasing air richness until over 99 per cent of the heat has been abstracted and over 99 per cent of the steam condensed. Thereafter the temperature falls with a marked knee in the curve, the exact position and shape of which depend on the proportion of air to steam in the original mixture.

This process is no longer rapid condensation but a matter of devaporization, to reduce vapor temperature and pressure, and increase partial air pressure, so that the air may be removed by a vacuum pump. This is carried out in a chamber external to the main condenser forming a devaporizer or cooler. Figure 2 illustrates the arrangement in which the flow of hot vapors and air taken from the bottom of the main condensing chamber are turned upward into a cooler from which the concentrated air is finally removed at the top. It will be noticed that this cooler is also of wedge shape, decreasing in area as the outlet is approached. The air is withdrawn by steam jet augmentors which discharge into an intercondenser section forming part of the cooler. The air at reduced vacuum is then withdrawn and compressed to atmosphere by secondary steam jets or a small reciprocating pump. In one case a single small pump is used as a secondary for two condensers, steam jets secondaries being installed as standbys.

The work of devaporization is done by cast-iron grids with fins, as illustrated in Fig. 3, which shows the grids as meshed when assembled in the cooler shell, where they are held in place and connected to the water spaces of the cooler by large cast-iron bushings. Cold circulating

water flows through the cores of the grids with only slight rise in temperature and then passes through the bottom group of tubes in the condenser.

Depending on the air leakage, the cooler devaporizes and cools the air down as close to the temperature of the cold circulating water as one degree, thus giving complete counter current action and maximum withdrawal capacity of the vacuum pump and protection against excessive reduction of vacuum due to heavy air leakage. The cooler taking care of the process at the knee of the curve, and the main condenser hot and active

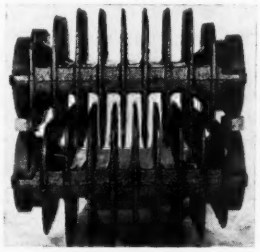


FIG. 3. TWO 12-IN. GRIDS MESHED

throughout its depth, the entire bulk of the circulating water can be heated with only one passage through the tubes. The circulating water may be pumped, therefore, at low head and power consumption, with high average rate of condensation or else at greatly increased velocities and correspondingly increased rates of condensation. The main supply of water passes directly through the upper and larger group of tubes and the remainder of the water, after passing through the cooler, goes through the lower and smaller group of tubes below the dock or partition.

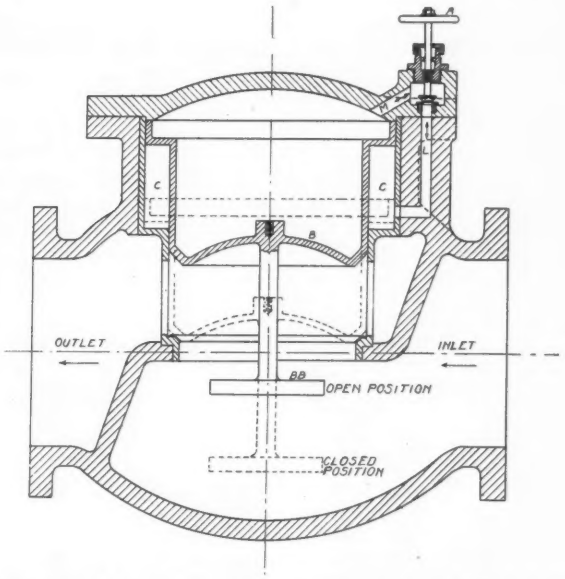
The rate of condensation in the condenser was found to vary substantially as the rate of condensation on a single tube, which depends on its diameter and material and the water velocity. There is more insurance against corrosion, as well as greater protection against reduction of vacuum by scaling and sliming when working the condenser at the higher and apparently less conservative condensation rates. The special features of this new type of condenser allow of considerable flexibility not only in the design of the condenser itself but in the selection and arrangement of the auxiliary equipment.

Automatic Double Cushioned Check Valve

AN AUTOMATIC check valve in which is embodied a new feature of control has recently been introduced on the market by the Golden-Anderson Valve Mfg. Co. This valve is shown in section in the accompanying figure.

The body is made of iron with a bronze liner down to and forming the seat. The piston is bronze and is designed to effect a cushioning action to either opening or closing with the object of eliminating water hammer or shock in the flow.

When the valve is in the closed position, the action is as follows: Initial pressure beneath the piston B forces it open, thus building up a pressure above the piston which is dissipated through the bypass M, L and valve A to an annular space C around the piston. The speed of opening is controlled by the amount of opening at the valve A. When the piston comes to rest the pressure above and that in the annular space around the piston is equalized, but the area above the piston on which this pressure acts is much greater than that on which there is an upward pressure so that there is constantly a pressure acting to close the valve. The flow through the valve, however, impinges on the plate BB below the piston and keeps the piston up in the open position. As soon as the flow stops there is no impingement on the plate BB or, if it reverses, the impingement is on the top side; thus the piston descends and tends to close the valve. It will be noted that before the valve seats the piston closes the bypass and therefore raises the pressure in the space C. When the valve seats, the pressure in this space is about twice as great



SECTION OF AUTOMATIC DOUBLE CUSHIONED CHECK VALVE IN OPEN POSITION

as that above the piston; but the area above is about 2.5 times that subject to the upward pressure, so that the valve remains closed until pressure builds up in the line under the valve.

Semi-Automatic Reseating Valve

BECAUSE OF the unusually severe service to which boiler blowoff valves are subjected, they, as a rule, quickly develop leaks and have to be reseated frequently. The function of the blowoff line is to remove scale and sludge accumulations from the boiler. All of this material must pass the valve seat and in so doing exerts a harsh abrasive action at this point. Both seat and disc are scored along line parallel to the steam flow and consequently when the disc is again seated, leakage occurs.

A valve manufactured by the Eckenroth Valve & Mfg. Co. for this class of service, to compensate for this wear, introduces a counter abrasion. As the valve is closed the disc rotates on the seat under a heavy spring tension. Fine particles of scale adhering to both the

disc and seat act as a valve grinding compound and grind down the seat in a direction at right angles to the original score lines. The seat is thus dressed down a slight amount each time the valve is operated. The wear around the surfaces offsets or compensates for the natural wear across them and a leak-proof valve is maintained.

The disc of this valve is fitted to a square shank on the stem so that both revolve as a unit. The spindle screws through a yoke mounted above the body of the valve and as the seating surfaces come in contact, compression of the spring, contained in the yoke, begins, and the disc will rotate on the seat with increasing pressure until these springs are entirely compressed. A lever is provided, on the end of which there is a pawl that engages lugs on the hand wheel, by means of which more force may be applied in seating the disc, when necessary.

Convenient Tap Changer for Power Transformers

BY BRINGING the operating shaft of the tap changer through a stuffing-box in the transformer cover and placing the operating handle outside, the Westinghouse Electric & Manufacturing Co. has made it possible for the tap changers to be operated very quickly and easily without removing either any of the oil or any covers of large power transformers.

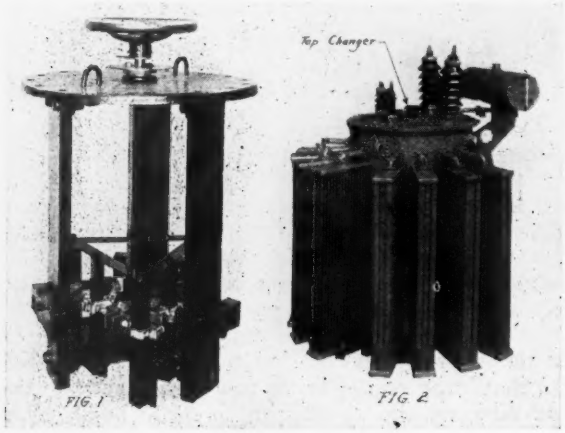


FIG. 1. TAP CHANGER BEFORE MOUNTING ON TRANSFORMER
FIG. 2. TAP CHANGER MOUNTED ON TRANSFORMER

Figure 1 shows the tap changer handle mounted on a large transformer and Fig. 2 shows the complete tap changer before it is mounted on the transformer.

C. R. D. Meier Now Controls Heine Boiler Co.

AFTER litigation that has extended over 16 yr. the control of the Heine Boiler Co. has been concentrated into the hands of C. R. D. Meier, son of the founder of the company.

It was in 1884 that Col. E. D. Meier and his brother Theodore founded the company for the manufacture of the then novel type of water-tube boiler, which they called the Heine Safety Boiler because of the lessened danger from explosion by separation of the contained water into smaller spaces. This name has since been changed to eliminate the word "safety," as the growth of the number of makes of water-tube boilers has destroyed the special significance of the word as applied to the Heine boiler. Also the company has enlarged its activities and builds practically all successful types of water-tube boilers in all sizes required.

The litigation arose from the setting aside of a block of stock for Adolphus Meier & Co., the firm of the Messrs. Meiers' father, which was insolvent, but had not been adjudged bankrupt. The object of setting aside the stock was that the debts of the old firm might be paid by the dividends from that stock, for the sons had assumed the debts of the father's firm as a moral obligation.. In time, not only were the debts paid, but a considerable reserve accumulated, in which another brother claimed a share. Thus the litigation started, and with death of the brothers and the increasing number of heirs, a complicated situation arose which seemed to be unsolvable.

C. R. D. MEIER

C. R. D. Meier, after education in Andover Academy and Harvard University, started as a salesman for the American Diesel Engine Co., and later worked in the plant of the Power and Mining Equipment Co. to gain experience. In 1910 he entered the Heine Boiler Co. as salesman, becoming the treasurer on the death of his father, and later the president on the death of E. C. Meier.

As a method of solving the legal tangle, Mr. Meier conceived the idea of buying up the interests of all the contending parties, and now after a long struggle and overcoming numerous obstacles set up by the other heirs and by competing financial interests, he has succeeded in the task which he set for himself.

Donald H. Amsbary Dies

DONALD H. AMSBARY died at his home in Pittsburgh, Pa., on Jan. 25. While he had been suffering for three or four days with what was considered an ordinary cold, his illness did not become serious until the morning of the day he passed away, when pneumonia developed.

Mr. Amsbary had been connected with the Pittsburgh

office of the Dearborn Chemical Co. for nearly 15 yr., and had been manager of that district for over 10 yr. He was 53 yr. of age.

Joseph A. Crenner, who has been associated with the Pittsburgh office of the company for many years, will succeed Mr. Amsbary as district manager.

News Notes

E. B. MERRIAM, formerly director of industrial relations, has been appointed executive engineer of the switchboard department of the General Electric Co.

THE ASHTON VALVE CO. announces the death of Albert C. Ashton, treasurer of the company, at St. Petersburg, Fla., Jan. 31, 1922.

THE WHITLOCK COIL PIPE CO. announces that it has recently secured the services of Geo. D. B. Van Tassel, superheater expert of Detroit, Mich., who will represent the company in that city and vicinity.

COTE BROS. MFG. CORP., with general offices at 1425 First National Bank Building, Chicago, has established branch offices during the past month in the following cities: New York, Philadelphia, Boston, San Francisco, Cleveland, Tampa and Denver.

C. L. DEWEY, who was associated with Carl Akeley in the invention and development of the cement-gun, and who has done extensive cement-gun contract work, has joined the forces of the Cement-Gun Construction Co., of Chicago, Ill.

HOMESTEAD SALES CORP., of 242 Lafayette St., New York City, has been appointed sole agent for New York and vicinity by the General Specialty Co., of Buffalo, N. Y. E. E. Jones of the Homestead Corp. reports a revival of interest in the steam specialties which his firm is handling, including valves and tube cleaners.

"STEEL MIXTURE" Fire Cement is the name of a new product which is being put on the market by McLeod & Henry Co. This material was developed to meet the demand for a bonding material to withstand high temperatures. It is a dry powder which can be mixed with water like ordinary fire clay. It will bond the bricks thoroughly and will not crack or shrink out of the joints.

THE WESTINGHOUSE Electric & Manufacturing Co. announces a marked increase in the sale of large power apparatus in 1922, with January sales of $1,500,000 in turbine-generators and condensers. Some of the companies purchasing this apparatus were Pennsylvania Edison Co. of Easton, Pa.; the Madison (Wisconsin) Gas & Electric Co.; the North Carolina Light & Power Co. Most of the business was included in 10 units.

MCCLAVE-BROOKS CO. has appointed K. S. Holmes, Jr., as representative in Cincinnati with office at 511 Gwynne Bldg. to handle the complete line of its products. The branch office at Charlotte, N. C., has been removed to Greenville, S. C., so as to be more centrally located to serve the southern textile field. A. R. St. John, the new manager of the New York office, has taken over his duties, but will also retain charge of the Boston office until a new appointment is made.

ON JAN. 1, the Gibby Engineering Co., of East Boston, Mass., took over the manufacture and sale of the Files hand stoker, formerly manufactured by the Files Engineering Co. This change is the result of the interest taken in the stoker by G. H. Gibby of the Gibby Foundry Co., which has been building the Files stoker for the past two years. A close co-operation with the foundry is thus secured, which will improve the quality of the product as well as the shipments. There will be no change in the organization of the engineering or sales shipments, but all communication relative to Files stokers should be addressed to the Gibby Engineering Co.

THE RATHBUN Jones Engineering Co., Toledo, Ohio, has appointed the Ingersoll-Rand Co., New York, general sales agent for Rathbun gas engines. The large sales organization and service department of the Ingersoll-Rand Co., combined with the fact that gas engines are used to drive compressors, pumps and other machinery which it manufactures, places it in a position to serve better the users of gas engines and other machinery.

W. H. PATTERSON, who has been associated with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., for the past 16 yr., has resigned to become vice-president of the Kaestner & Hecht Co., electric elevator builders, Chicago. Mr. Patterson graduated from the Electrical Engineering Course of Purdue University in 1905. He has been prominently identified for a number of years with the development of motors and control apparatus for application to cranes, compressors, elevators, hoists, and machine tools.

THE NEW ENGLAND POWER CO. has begun work on a new hydraulic power plant on the Deerfield River at Whitingham, Vt., which it is estimated will cost in the neighborhood of $6,000,000. The dam, the chief feature of the work, will be 200 ft. high, a quarter of a mile long, and will create a storage reservoir more than 10 mi. long.

Although it is expected that the job will be completed in 1924, the dam will be finished first so that it will catch the flood waters in the spring of 1924. A power plant, capable of delivering 10,000 hp. will be built below the dam and will supply current for neighboring industries and utilities.

A large amount of preliminary work will be necessary on this job, including the construction of a 1600 ft. 25 ft. diameter tunnel through solid rock through which the river will be diverted to allow work on the dam.

U. S. CIVIL SERVICE COMMISSION announces examinations for Master Machinist (Inside), Master Machinist (Outside) and Master Electrician on March 8, 1922, at San Francisco, Calif., Portland, Oreg.; Seattle, Wash.; Boston, Mass.; New York, N. Y.; Philadelphia, Pa., and Norfolk, Va., to fill vacancies at the U. S. Naval Station, Pearl Harbor, Hawaii, at $10.96 a day, and in positions requiring similar qualifications, at this or higher or lower salaries.

Appointees for the position of Master Machinist will be required to read blueprints, make working sketches of machinery parts, design special jigs and fixtures of various tools, must be familiar with the strength of various materials and their use, and able to lay out work from blueprints. They must also be thoroughly familiar with modern shop practices as regards all forms of machine tools, laying out and routing work involved in marine and other machinery. Applicants must have completed a common-school or equivalent education and

have had at least 8 yr. practical experience as machinist subsequent to completion of a 4-yr. apprenticeship, at least 3 yr. of which must have been in a supervisory capacity. The successful completion of each year of a high-school course or course in a college or university of recognized standing along the line of mechanical or electrical engineering will be accepted as equivalent to 9 mos. of the experience as apprentice or machinist.

The duties of Master Electrician are such that the appointee should be able to assume complete charge of the installation, operation and repair of all electrical apparatus, such as motors and generators, telephone and lighting systems, storage batteries and all forms of electrical instruments used in the naval station, as well as the preparation of the plans and specifications of all electrical apparatus used in connection therewith. Applicants must have had at least 10 yr. of experience along the line of electrical engineering, dealing with apparatus similar to that used in the naval service, not less than 3 yr. of which must have been in a responsible position, either with the Government or with a private concern manufacturing, designing, installing, or repairing such apparatus as specified in the statement of duties. The successful completion of each year of an electrical engineering course in a college or university of recognized standing will be accepted as equivalent to one year of general experience. Applicants must not have reached their sixty-fifth birthday on the date of examination.

Apply for Form 1312, stating the title of examination desired.

Catalog Notes

ICE AND REFRIGERATING machinery catalog No. 4 was recently issued by F. W. Niebling & Co., Cincinnati, O.

A FOLDER illustrating the Marion reversible clutch has been received from Marion Machine, Foundry & Supply Co., Marion, Ind.

BULLETIN No. 123, of the Goulds Manufacturing Co., Seneca Falls, N. Y., descriptive of the newest addition to the company's pump line, namely the Goulds steam turbine driven centrifugal pump, was recently received.

A NEW CATALOG has just been issued by the Chicago Fuse Mfg. Co., of Chicago, on electrical protecting materials and conduit fittings. This catalog contains 96 pages with 445 illustrations.

IN LEAFLET 3665, recently issued by the Westinghouse Electric & Manufacturing Co., motors for elevator service are completely discussed and illustrated. It is shown how satisfactory elevator service may be obtained. Further, it points out how to select the elevator motor, for which purpose several formulas are given.

ELLIOTT CO.'S Bulletin "A" on Strainers, just published, is devoted mainly to the company's Twin Strainers, describing and illustrating the different types together with special types such as motor operated Twin Strainers and Twin Oil Strainers; also Elliott intake strainers and a new type of single strainer. The introduction takes up the problem of straining water, oil, tar, sugar juices, etc., and treats of uses for Twin Strainers in power and industrial plants.

HYTEMPITE IN THE POWER PLANT is the title of a bulletin presenting information with illustrations regarding refractory linings and the use of Hytempite in power plant work, as well as its use in connection with Carbosand for baffles, patching boiler settings, etc.; also discussing the uses of Insulbrix and showing comparative heat losses of uninsulated and insulated walls. The manufacturer is Quigley Furnace Specialties Co., New York.

IN "TUBE FACTS," a pamphlet recently brought out by Scovill Mfg. Co., Waterbury, Conn., is published scientific data in regard to brasses, bronzes, nickel silvers and pure nickels, the booklet dealing also with the different processes involved in the manufacture of seamless tubing to produce a product of alloys best suited to meet various requirements, and showing how metallography is applied in its manufacture. Condenser tube failures are discussed, micrographs illustrating corrosion of Muntz metal and tube leakage due to imperfections in the metal. Season cracking is also explained.

THE AMERICAN STEAM GAUGE & VALVE MFG. CO. has recently put on the market a new recording thermometer. Unlike some recorders, this new product is actuated by different methods, depending on the purpose for which it is to be used. Either saturated vapor expansion, inert gas or other liquids are employed. It has an ingenious chart button which permits of removal of the chart by giving the button a quarter turn, and prevents loss of the button. A pen lifter automatically raises the pen from chart when door is opened. The instrument is described in a new folder being issued by the company.

THE JEFFREY MANUFACTURING CO. is issuing a new catalog, No. 345, entitled Coal and Ashes Handling Machinery for Boiler Houses. Twelve distinctive types of Jeffrey Power House Equipments for economically meeting a wide range of capacity requirements in various sizes of plants are illustrated and described in this catalog. It will undoubtedly be of assistance in the selection of the proper type of equipment for new power houses, installation of new equipment which can later be extended as conditions warrant; making temporary extensions to present equipment or replacing worn out or inadequate handling machinery.

INSTRUCTION BOOK FOR CENTRIFUGAL PUMPS is the title of bulletin W-605-D, recently issued by the Worthington Pump & Machinery Corporation. While this volume is called an instruction book, it might as well be called a handbook for operating engineers on the subject of pumps.

The book contains some exceptionally meaty and informative data on the erection, installation, dismantling and repair of centrifugal type pumps. The information on the subjects of foundation, alinement, piping, drains, packing, water scale, starting, pump characteristics, care and operation is given in detailed form and is appropriate for the needs of the plant engineer.

On page 8 is given a chart showing the maximum allowable water temperature for a given suction lift and capacity. It is the first information of this kind which, to the best of our knowledge, has been published. On page 18 is a comprehensive capacity-efficiency chart which should be of great value to the designing engineer.

The publicity department of this company will be glad to send copies of this bulletin, W-605-D, to interested readers.